

Textbook of Male Genitourethral Reconstruction

Francisco E. Martins
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Editors

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I would like to express my appreciation and gratitude to several surgical mentors, namely Stuart Boyd, Martyn Vickers, Willem Oosterlicnk, Miroslav Djordjevic, Richard Santucci, Andre van der Merwe, Margit Fisch, Sanjay Kulkarni, Guido Barbagli, Tony Mundy, Branco Palma, José Maria Alves and Tomé Lopes, and many others, who taught, supported, and encouraged my vocation in the field of urologic reconstruction. To all the patients I had the privilege to treat, care for, learn from, and who teach me daily the meaning of dignity in the face of adversity, my sincere thanks. To the ones I love, most especially my wife and colleague Natalia and our children Filipe, Daniela, and Tomás for the unswerving inspiration, strength, love, support, and sacrifice they shared with me for the long hours dedicated to this project and life in general. I certainly would not have made it without them.

Francisco E. Martins

I would like to dedicate this book to my wife, Dr. Jyotsna Kulkarni, for being my partner in life and surgery and also to my surgical mentors Dr. P K Bharucha, Mr. Michael Heal, Mr. Richard Turner-Warwick, Prof. Guido Barbagli, and Prof. Tony Mundy for shaping my career.

Sanjay B. Kulkarni

I would like to dedicate this book to my surgical mentors and peers who taught me both the art and science of surgery: Steven K. Wilson, Robert E. Brannigan, Kevin T. McVary, Landon Trost, Patrick H. McKenna, Georgios Hatzichristodoulou, Jon L. Pryor, Eduardo T. Fernandes, Manoj Monga, Joe Y. Lee, Sean P. Elliott, Alexander S. Tretinyak, J. Kyle Anderson, and Benjamin K. Canales.

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Foreword

This is one of the most complete and well-done books published on the topic of male genitourethral reconstruction. The editors, Professors Martins, Köhler, and Kulkarni, are to be congratulated on such a refined and finished product. This book assembles a group of illustrious international authors that cover all topics in such detail to assure that any student of a male reconstructive surgery has the latest and most complete information on the topic. It is well illustrated to demonstrate the surgical techniques and also includes in-depth discussions regarding the potential complications like urethral stricture recurrence and how to manage it.

The book is thoughtfully designed into four sections. Part I deals with male urethral reconstruction which includes 34 chapters and covers in great detail all the information that one can imagine on the topic.

Part II deals with penile and scrotal reconstruction which includes some 23 chapters covering such areas as priapism, Peyronie's disease, and varying techniques of penile prosthesis implantation, among other terrific chapters.

Part III is devoted to urinary incontinence and neurourology and is covered in great completeness over the six chapters.

One of the unique characteristics of this book is Part IV on gender-affirming surgery. The four chapters on this topic provide the guidelines necessary when considering this complex surgery. The experts detail the best approaches and thoughts on these challenging reconstructions.

This is an impressive textbook, noted for its completeness and contributions from an array of distinguished international authors. It should be on everyone's shelf who is interested in genitourethral reconstructions.

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Foreword

As a purchaser and author of multiple textbooks, I know that very few physicians read the tome from cover to cover. Most of us pursue the following scenario. The Table of Contents is perused for the subjects and authors of urgent interest to stimulate the buying decision. Upon acquisition of the textbook, the usual physician eagerly embraces and studies a few chapters of their focus. Finally, the book is placed in their library for future reference when a clinical situation stimulates the need for information. The decision to purchase, the initial excitement to read an authority's take on a favorite subject, and the eventual relegation of the textbook to the bookshelf are events, I believe, occur with every medical textbook. Whether the book becomes a "treasure" of the consumer's library is a function of how meaningful the future use as a reference is.

In my opinion, the *Textbook of Male Genitourethral Reconstruction* by Köhler, Kulkarni, and Martins is, in the lingo of Amazon.com, a "fulfillment center." The reader is stimulated to acquire this phenomenal textbook because it is brim full of authoritative authors writing on tightly focused subjects of male surgical reconstruction. Unlike other reconstructive texts, there is no regional slant because the authorities come from all over the world. Sure, the "usual suspects" from the USA are included as authors. The real riches, however, are the depth and breadth of this exceptional text. The 72 chapters, crafted by key opinion leaders from 25 different countries, are well written and beautifully illustrated with surgical drawings and medical photography. Paging through the various chapters of this extensive reference source, I can confidently predict the editors have created a treasured acquisition for the male reconstructive surgeon's bookshelf!

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Preface

I will not cut persons laboring under the stone, but will leave this to be done by men who are practitioners of this work. (Excerpt from Hippocratic Oath)

Here, Hippocrates acknowledges his lack of expertise in the surgical treatment of a urologic condition, leaving it to be done by more experienced hands. Our *Textbook of Male Genitourethral Reconstruction* hopes to teach and prepare the reader in all facets of male genitourinary surgery. Divided into four sections, this book systematically covers urethral reconstruction, penile and scrotal reconstruction, urinary incontinence and neurourology, and gender-affirming surgery. The editors have handpicked a truly international team of world-class surgeons to share their surgical acumen and wisdom. We hope that through knowledge obtained from this book, you feel comfortable treating the patient laboring under the stone or otherwise.

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Sanjay B. Kulkarni
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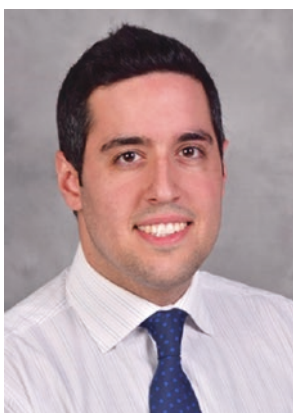
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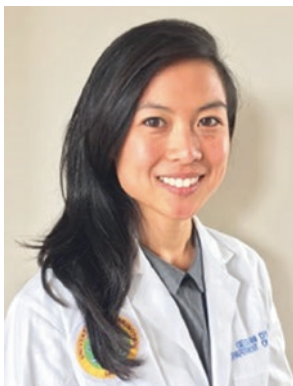


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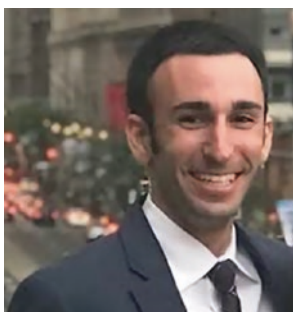
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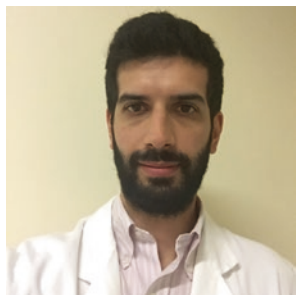
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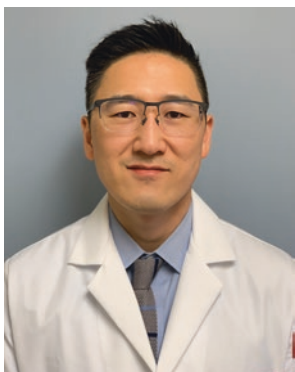
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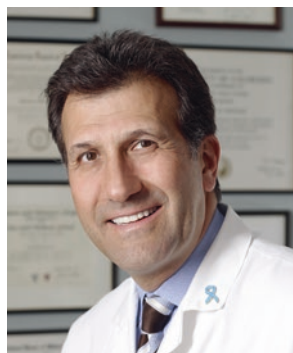
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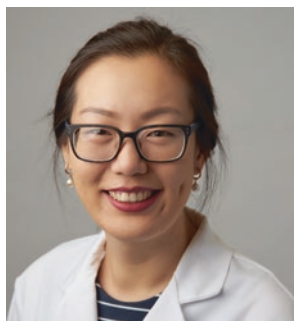
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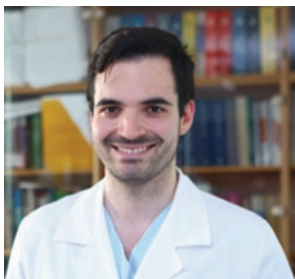
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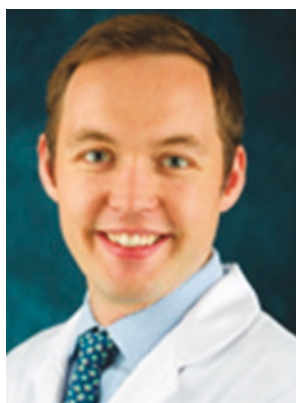
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Part I

Urethral Reconstruction

History of Urethral Stricture and Its Treatment

1

Devang Desai and Francisco E. Martins

1.1 Ancient Civilizations

“Everything that is happening now has happened before: there is nothing new under the sun” Bible, Ecclesiastes 1:9.

The earliest reports describing attempts to deal with urethral stricture date back to ancient India, and Sushruta in particular, in the sixth century BC (Fig. 1.1). He described in the Ayurveda urethral dilatation by means of a reed catheter lubricated in ghee (clarified butter) [1]. This depiction is present in Hindu medicine scriptures. At the same time the Chinese depicted the use of bamboo catheters for similar use. Epicurus, a Greek philosopher, was known to commit suicide when he could no longer dilate his own stricture (Fig. 1.2). Therefore, urethral dilatation is considered the oldest method of urethral stricture management with its description found in the earliest papyruses and clay tablets.

Hippocrates, who lived during the fifth and sixth centuries BC, described certain urethral conditions including urethral stricture and abscess. Lithotomy was already practised in



Fig. 1.1 Sushruta (c. seventh or sixth century BC), founder of ayurveda medicine, was a physician in ancient India, known today as the “Father of Indian Medicine” and “Father of Surgery” for inventing and developing surgical procedures

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Greece as well as some parts of the Byzantine and Islamic Civilizations.

In the first century of the Christian era, Cornelius Celsus, in the Roman Empire, devised the technique of external urethrotomy to remove a calculus stuck behind a stricture. He also gave a description of a S-shaped catheter. In the following

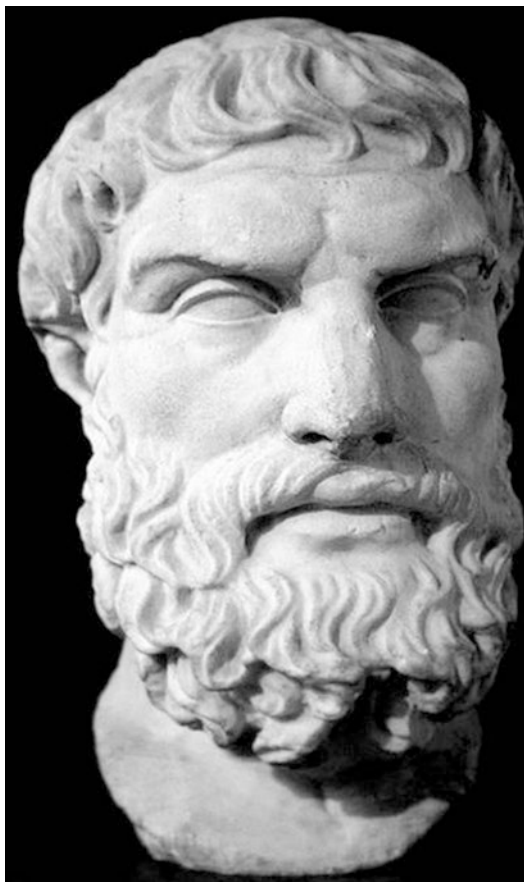


Fig. 1.2 Epicurus, Greek philosopher (341 AC–270 AC): “I have written this letter to you on a happy day to me, which is also the last day of my life. For I have been attacked by a painful inability to urinate, and also dysentery, so violent that nothing can be added to the violence of my sufferings...”

century, Galen also alluded to this subject, but nothing further significant seemed to have been achieved in the ensuing centuries, perhaps with very few exceptions, neglecting and abandoning these patients to die rapidly of urinary retention or to develop fistulae and to linger in a sad and forlorn existence.

1.2 Through the Middle Ages...

Until the Middle Ages, the treatment of genitourinary problems in general, and urethral strictures in particular, was regarded as unworthy of

physicians’ efforts and was left in the hands of itinerant quacks and charlatans with vague ideas on the subject. From the eleventh to the fifteenth centuries medicine and surgery were mostly dominated by religious superstitions and witchcraft which produced an almost completely sterile period in the advancement of urethral stricture management. Johannes d’Arderne in the fourteenth century and de Veja and Diaz in the sixteenth century made isolated attempts at external and internal urethrotomy, respectively, and were the exceptions to this bleak period. However, internal urethrotomy would be re-established only in the nineteenth century by Jean Civiale of Paris [1].

During the Renaissance period, and for about 150 years until the seventeenth century AD, the only known and practised operation was external lithotomy, and these patients were “treated” again mostly by itinerant nonphysician practitioners.

In 1520 AD the first recorded outbreak of epidemic gonorrhea occurred which gradually brought attention back to the subject of urethral stricture. Urethral stricture began to be regarded as caused by obstructing growths, and not due to a constriction in the urethral lumen, an idea that persisted until the eighteenth century. Ambroise Paré (1510–1590), a French barber surgeon and one of the most notable surgeons of the European Renaissance and regarded by some medical historians as the father of modern surgery, devised an instrument to scrape the ‘carcinomas’ (stricture) until internal urethrotomy came to vogue. Ambroise Paré served the kings Henry II, Francis II, Charles IX and Henry III (Fig. 1.3). In his kind and strong religious devotion he would refer to his patients’ successful outcomes as “I treated him, God cured him!”. However, in the seventeenth and early eighteenth centuries, with sporadic exceptions, surgery was largely in the hands of barbers, executioners and mountebanks.

In the eighteenth century, where surgical teaching was controlled by the French, John Hunter (1728–1793) in Scotland made bold attempts at open removal of bladder and urethral



Fig. 1.3 Ambroise Paré, French barber surgeon (1510–1590). Description of urethrotomy: “A silver weir, sharp at the upper end, is to be passed in as far as the obstruction, then by oft thrusting it in and out, it may wear and make plain the resisting caruncles”

stones, but the absence of anesthetics and the “plague” of deadly sepsis, to which all wounds were inevitably exposed, made his efforts fruitless and progress slow. However, through his dynamic work and curious mind, he classified urethral strictures as permanent, spasmodic (rare) or mixed. He thought that spasmodic contraction of the urethral muscles associated with stricture could result in retention [1]. He treated strictures with dilators and caustics (caustic soda or silver nitrate) at the end of bougies, methods already recommended by Paré and others since the fifteenth century. The word bougie originated from the Algerian coastal town ‘*Bujiyah*’ from where came the best wax for French candles which were used as bougies [2, 3] (Fig. 1.4). Consequently, the treatment of urethral strictures was essentially by means of intermittent bougienage. At the same time a ‘sound’ was used to identify bladder stones and hence, the words sound and bougie became interchangeable [1].



Fig. 1.4 Historic map of Algiers and “Béjaia” by Ottoman Admiral Piri Reis in 1513. “The wax bougie is the one in general use...with respect to wax bougies, before introducing them into the urethra, you should always warm them by the fire, for the purpose of rendering them soft; when, if they are introduced into the urethra, and pass through the stricture, you will ascertain the distance at which it is situated from the orifice and the form and size of the stricture will be modelled on the bougie”

1.3 From the Modern Period Until Early Twentieth Century

Since the early 1880s, urethral dilatation underwent somewhat innovating improvements. It could be performed in three different ways: gradual, continuous or forcible, which, nonetheless, rendered the patient “never dischargeable” in most instances. This originated the common doctrine, still in vogue in some minds, that “once

a stricture, always a stricture"! In 1822, Theodore Ducamp (1793–1823) introduced the concept of balloon dilatation to improve serial dilatation methods [4]. In 1836, Leroy d'Etiolles is credited with the invention of the "*bougie à boule*", fine filiform bougies with modified distal extremities to facilitate their passage, which were similar to the bougies used today. During this early period of the nineteenth century, cauterization of urethral strictures was also popular and standard of care with Hunter, Home, Ducamp, Lallemand and Whatley among its firm advocates. Because caustics were typically associated with severe urethral complications, this treatment rapidly fell out of favor [1].

In 1786, Chopart contributed to the establishment of the French operation of la "*Boutonnière*" to treat urinary retention and obliterative strictures [1]. This operation involved a longitudinal incision in any location of the urethra for the removal of a calculus, this opening resembling a buttonhole, hence the suggestion for its name. For simpler, nonobliterative strictures, urethral dilatation and/or bougienage remained popular.

In 1795, the silver catheter with concealed lancets appeared for internal urethrotomy. This silver catheter had a cutting blade that protruded through its extremity to cut through the stricture. It became very popular and was the precursor of future internal urethrotomies.

In 1817, Jean Civiale of Paris (1792–1867), invented a practical form of internal urethrotomy operating from within outwards. He recovered internal urethrotomy which had been long abandoned between the sixteenth and nineteenth centuries. In 1832 he also devised a surgical instrument, the lithotrite, to perform transurethral lithotripsy, the first known minimally invasive surgery, to crush bladder stones, without laparotomy [5].

In 1829, Fisher of Baltimore is credited as being the first to attempt anterior urethroscopy with an archaic apparatus. In 1873, the Austrian dermatologist Joseph Grünfeld (1840–1910) performed open urethroscopy with light reflection and was also credited to have greatly contributed to the modern urethroscopy at the Clinic for Syphilitic Patients in Vienna, "*Allgemeine*



Fig. 1.5 Endoscopic examination (urethroscopy) according to Josef Grünfeld (1840–1910). He preferred to have the patient sit on a "*Speculiertisch*" (a special examination table) for better regulation of lighting and positioning of the endoscope in this position. (From Reuter et al. [6])

Poliklinik" (Fig. 1.5) [6]. However, no satisfactory results were obtained owing to defective illumination and an absent (at the time completely unknown) optical magnification system. These inventions had to wait for Thomas Edison (1847–1931), an American inventor and successful businessman, who invented the incandescent electric light bulb, and Harold Hopkins (1918–1994), a British physicist, who invented the zoom lens, coherent fibre-optics and rod-lens endoscope, which revolutionized modern optical design and endoscopic surgery in the twentieth century [3, 7].

In 1836, James Guthrie (1785–1856), a British military surgeon, described urethral dilatation and made observations advocating internal urethrotomy with the silver lancellated catheter asserting that the procedure should only be used in the anterior urethra.

In 1848 and 1876, Maisonneuve and Otis, respectively, fashioned their blind internal urethrotomes which were passed without any visual control through the urethra in order to incise the strictured area. Jacques-Gilles Maisonneuve (1809–1894) conceived in 1845 the idea of a filiform guide which allowed the urethrotome to advance and cut the stricture [8, 9]. The major limitation of these urethrotomes was the need for

the urethral caliber to be large enough to allow their passage. Although internal urethrotomy was improved by Civial, Maisonneuve, Reybard and Charrière in Paris, the latter was awarded the “*grand prix d’ ARGENTEUIL*” for his essay “*Traité pratique des retrécissements du canal de l’urèthre, Paris, 1843*”. Urethrotomes would later be developed by Joaquin Maria Albarran (1860–1912), Ernet Desnos (1852–1925) and Fessenden N. Otis (1825–1900). At around the same time Fessenden N. Otis, a professor of genitourinary diseases at the New York College of Physicians and Surgeons described the graduated bulbs, or bougies-à-boule and later introduced his “urethrameter” or urethrometer to determine the correct size of a sound and bougie for urethral dilatation [8, 10]. Otis also produced various mechanical dilators and in 1870 he developed his 2-bladed dilating urethrotome [10, 11]. In 1892, Felix M. Oberländer (1849–1915) designed the first direct vision internal urethrotome with an incorporated light source [12]. This instrument also had a separate working channel for introduction of different knives that allowed the incision of urethral strictures under visual control.

The introduction of chloroform anesthesia in 1857 by Sir James Young Simpson (1811–1870) and followed later by the work of Lord Joseph Lister, opened the door to deep surgical intervention, reducing the patients’ suffering due to pain and gradually improving the often fatal sequelae of sepsis [13]. Towards the end of the nineteenth century, significant changes were witnessed. Excision of urethral stricture began to be practised, however with a high failure rate. The use of caustics was losing popularity as well as aggressive methods of forcible and speedy dilatation. Mechanical dilators such as those designed by Kollmann and Oberländer were being increasingly used. In 1895, impassable strictures associated with urinary retention underwent a form of external urethrotomy with operations conceived by Wheelhouse or Edward Cock (1805–1892) [1].

External urethrotomy is one of the oldest surgical procedures described for complex strictures. However, open surgery for urethral strictures was largely reserved for very complex, desperate cases. Gouley, an American surgeon

from New York, was one of the pioneers who practised this surgery with considerable success. Later, Syme also favored external urethrotomy and felt that all strictures could be treated this way as long as a sound could be passed retrogradely through the stricture, and, occasionally, antegradely through a cystostomy. He considered internal urethrotomy a “bloody, painful and dangerous procedure”.

Since 1900 external urethrotomy was largely replaced by suprapubic diversion for cases of impassable stricture complicated by urinary retention [14].

1.4 From the Twentieth Century up to the Present Time: The Great (R)evolution in Urethral Stricture Management

Regarded as one of the most important ancestors of the modern urethral surgery, Kirill Mikhailovich Sapezhko (1857–1928), from Chernigov, Ukraine, was the first to use an oral mucosal graft to augment a strictured urethra in 1894 (Fig. 1.6) [15, 16]. He stated “I am deeply convinced that tissue transposition in the future will be widely used and will become a fruitful acquisition in surgery [15]. Graham Humby (1909–1970) from London, would report on this procedure for a one-stage operation for hypospadias nearly five decades later in 1941 [17]. The procedure was revived 102 years later in 1992 by Bürger and Dessanti, in 1993 by El-Kasaby, and in 1996 by McAninch and Barbagli, respectively [18–22]. Nonetheless, modern urethroplasty surgery is considered to be standing largely on the shoulders of pioneering giants, such as Dennis Brown, Hamilton Russel, Bengt Johanson, Charles Devine, John Blandy and Richard Turner-Warwick. Over the second half of the twentieth century, urethral reconstruction has shifted from mainly two-stage procedures to the use of grafts, then onto flaps, and currently has moved back to mucosal grafts, especially oral (cheek, lip and tongue) grafts. Dugas, in 1836, reported the first case of complete resection of

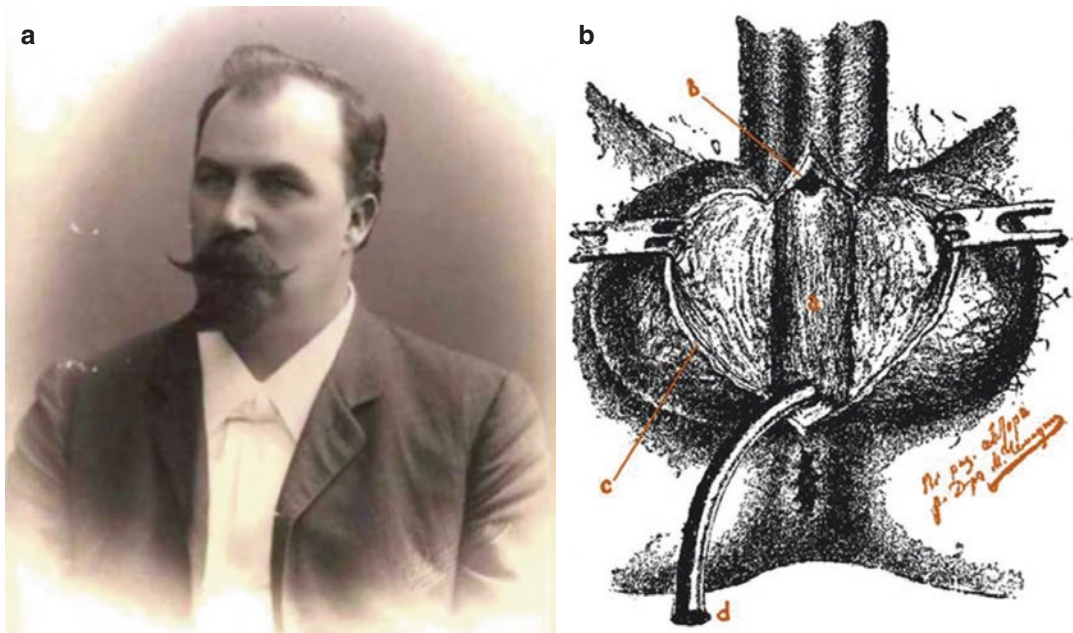


Fig. 1.6 (a) Professor Kirill Mikhailovich Sapezhko, Odessa (Photo by B. Gothlieb, 1902). (b) First case: (a) underlying tissues, (b) distal end of urethra, (c) split scrotum, (d) catheter. (From Sapezhko [15])

the urethra for the repair of a stricture. However, Huesner is credited with performing the first excision and anastomotic urethroplasty in 1883. Several other surgeons, such as Mayo Robson in 1884 and Guyon in 1892, followed. In 1906 Pasteau and Iselin reported on their staged urethroplasty in which the stricture was excised and the urethral ends were marsupialized to the skin followed by a second stage with tubularization.

Hamilton Russel (1860–1933), an English-born Australian surgeon and a student of Joseph Lister's at King's College Hospital, reported on a variation of this staged, buried strip regeneration technique in 1915. In his 1915 seminal lecture on urethroplasty, he gave a detailed description of his surgical technique of what is known today as urethral excision and primary anastomosis. He stressed the fact that stricture excision was rarely performed due to its technical difficulty and uncertainty in its results. Dennis Browne (1892–1967) modified the Russell technique of buried urethral epithelium strip for hypospadias reconstruction. Richard Turner-Warwick further refined Russell's procedure decades later as a "scrotal inlay technique". However, the success

of urethral excision and anastomotic urethroplasty only became apparent around the mid-1980s when it was accepted as an excellent method of reconstructing short bulbar strictures. Urethral reconstruction with tubular autologous grafts, such as saphenous vein, appendix, peritoneum, ureter, etc., have also been reported along the way with unsurprisingly uniform failure.

In 1953, Bengt Johanson [23], a Swedish surgeon from Stockholm, described his two-stage technique of ventrally marsupialized penile urethroplasty based on the principle of a buried intact urethral epithelial strip that Dennis Browne used for hypospadias [24]. The second stage was carried out 6 months later. However, the original groundwork for this type of repair was carried out by Duplay in 1874. Johanson noted that excessive proximal and distal urethral mobilization and anastomosis for long urethral defects resulted in ventral penile curvature. He also noted that if scrotal skin was included in the reconstruction, hair follicles continued to grow with its inherent sequelae. Nonetheless, Johanson's staged urethroplasty paved the way for contemporary staged reconstruction with grafts.

Charles Devine Jr. (1923–1999), along with his plastic surgery colleague and friend Charles Horton, pioneered several surgical innovations that are still the standards of care worldwide today. For the next two decades following Johanson's staged urethroplasty, the skin patch grafting technique developed by Devine for single-stage urethroplasty became the most commonly used method of reconstruction [25].

In the mid-1960s, the pendulum swung to the use of fasciocutaneous flaps, initially based on perineal and scrotal skin largely for two-staged reconstruction, and followed later by penile skin flaps for single-stage urethral reconstruction. In 1968, John Blandy (1927–2011) reported and popularized the urethroplasty technique by scrotal flap for long urethral strictures [26]. In the same year, Ahmad Orandi reported his technique of one-stage urethroplasty with the use of longitudinal and ventral penile shaft skin flap with less complications than those associated with the use of scrotum, which, therefore, attracted more followers [27].

In 1985 and 1993, John Quartey (1923–2005) from Ghana, and Jack McAninch from the USA, respectively, described their methods of obtaining penile/preputial island flaps for reconstruction of longer strictures [28, 29]. Onlay flap urethroplasty thus replaced grafts as the method of choice for urethral reconstruction for another decade or so, with the pendulum again shifting to grafting, when El-Kasaby reported the successful use of buccal mucosa patch graft urethroplasty in 1993 [30]. From then onward, only modifications and variations of oral mucosa graft applications have been reported (Ventral – Morey and McAninch 1996, Dorsal – Barbagli 1996, Combined Dorsal plus Ventral – Palminteri 2008) [31]. In 2001, Asopa described a technique of dorsal inlay oral mucosa graft patching through a longitudinal ventral urethrotomy, avoiding extensive mobilization of the urethral bed [32].

In 2000, Sanjay Kulkarni from Pune, India, reported his penile invagination technique with dorsal oral mucosa onlay graft augmentation for long segment and panurethral stricture reconstruction [33]. In 2009, he modified his former technique including one-sided urethral dissection

to preserve blood supply to the urethra and reduce the incidence of ventral curvature [34].

In 2010, Barbagli supported the Blandy flap perineal urethrostomy for complex urethral strictures which apparently were not amenable for reconstruction or for patients unfit or unwilling to undergo definitive surgery [35].

Reconstruction of the posterior urethra has also undergone significant advances over the last 150 years or so. The majority of posterior urethral reconstructions are related to post-pelvic fracture urethral injuries (PFUI). The modern history of pelvic fracture urethral injury and pelvic bone fracture are closely related. Pelvic fracture management has evolved significantly since the seminal work of Joseph-François Malgaigne (1806–1865), a French surgeon who was the first to recognise and describe a vertical “shear” pelvic ring injury with bilateral sacro-iliac joint dislocation and associated anterior fractures of the pubic rami [36]. Several of these patients sustained injuries after falling or jumping from heights, or after being crushed or run over by horse-drawn carriages. Despite a “double fracture” with displacement of the hemipelvis as a result, urethral injury with or without vesical injury was common. The introduction of X-ray technology in 1895 by the German physicist Wilhelm Conrad Röntgen (1845–1923) dramatically improved the diagnostic accuracy and classification of these injuries. Technical recommendations for fracture reduction and immobilization by Sir Astley Cooper, Sir Reginald Jones, and Sir Frank Wild Holdsworth from England contributed significantly to the mitigation of acute hemorrhagic shock and associated mortality as well as to the overall improvement of care of these patients [37].

PFUI was uniformly fatal due to urinary outflow obstruction, extravasation, sepsis and uraemia until Verguin determined how to perform suprapubic cystostomy with open antegrade-retrograde railroading of a perineal catheter into the bladder in 1757 [38]. This method was associated with a high incidence of complications. For the next 150 years, survival was high and randomly dependent upon ad hoc circumstances until management of associated injuries and

imaging improved. Mortality rates dropped from close to 100% in 1757 to 78% in 1907 and 23% in 1942 [39].

Hugh H Young (1870–1945) originally described primary open anastomotic repair for PFUI in 1929 [40]. The goal was to evacuate the pelvic hematoma and achieve a watertight anastomosis to avoid urine extravasation with its inherent and inevitable serious complications, especially significant intra-operative blood loss (>3 L on average) and eventually death. Currently, this approach is only used in cases of a simultaneous bladder neck or rectal injury. In 1934, primary open realignment was first reported by Ormond and Cothran, and later by Wilkinson in 1961, as an easier alternative to Young's primary open repair [41, 42]. This can be achieved by retrograde catheter placement under direct vision, sound to sound, sound to finger and combined antegrade-catheter guided retrograde catheter placement. Primary open realignment does not actually produce anatomical realignment of the urethra; at best it re-establishes urethral continuity. Primary endoscopic realignment includes antegrade or retrograde catheter insertion over a guidewire at flexible cystoscopy. The rationale for early endoscopic realignment is to avoid the "morbidity" of prolonged suprapubic catheterisation and to prevent/shorten any consequent strictures [43, 44].

Primary suprapubic cystostomy and delayed urethroplasty (>3 months after trauma) was initially proposed by Johanson in 1953 [45]. In 1962, Pierce performed total abdominal pubectomy for better exposure of the posterior urethra [46]. In 1968, Paine and Coombes accomplished an end-to-end anastomosis after resection of scar tissue and pubic bone through an abdominal approach [47]. In 1973, Waterhouse described a combined abdomino-perineal approach with wedge pubectomy in all patients with PFUI [48, 49]. In 1977, Richard Turner-Warwick separately used the abdomino-perineal approach only for patients where an anastomosis could not be made perineally, and only removed a portion of the abdominal surface of the pubis, sufficient to gain access to the apex of the prostate [50]. He also conceived a modified omentoplasty technique to

support and protect the posterior urethroplasty [51]. This was an era in which complicating features such as associated pelvic abscess, urethrorectal, urethro-cutaneous and complex bladder-base fistulae were not uncommon, all of which would require an abdomino-perineal approach, facilitated by pubectomy. Also in this period of time abdominal exposure with pubectomy was deemed necessary for urethral defects of >2 cm long, which comprised a significant number of cases [52, 53]. In 1986, George Webster described a four-step progressive/elaborated modification of this procedure that avoided abdominal exposure and pubectomy for long urethral injuries, entailing only a wedge inferior pubectomy via the perineum, allowing better perineal exposure of the prostate apex for a more direct, tension-free anastomosis [54]. The four steps of Webster's sequential reconstruction included: urethral mobilization, corporal separation, inferior wedge pubectomy and urethral supracrural re-routing. By this time, staged scrotal-skin inlay procedures were uncommon for PFUDDs and reconstruction was generally by this perineal anastomotic repair or by the Waterhouse abdomino-perineal approach.

In 2011, Andrich and Mundy developed the non-transecting bulbar urethroplasty, driven by concerns over the potential morbidity associated with dividing the urethra, therefore compromising spongiosal blood flow, with the aim of achieving the same success as EPA without the morbidity associated with transection [55].

Tissue engineering solutions have been suggested in the field of urology for many decades, but despite technical success in the laboratory, clinical application has been modest (Fig. 1.7). The literature contains a number of reports regarding different experimental tissue-engineered products, but only few reports on the use of these materials in humans with urethral strictures [56, 57].

Finally, considering the steady increase in the incidence of urethral strictures, especially post-traumatic stenosis, in developing countries (China, India, African Continent), the World Health Organisation should develop a new investment framework to achieve dramatic worldwide



Fig. 1.7 Tissue engineering – the new frontier in urethral stricture management

health gains in the management of tissue-engineered urethral reconstruction in the near future [58].

Most of the research to date in urological tissue engineering is done in animals. Before these engineering techniques can be applied to humans, further studies need to be performed.

1.5 History of Urethral Stricture Management: A Milestone Synopsis

1.5.1 Historical Landmarks

- Ancient India (sixth Century BC) – Sushruta urethral dilatation with ghee-lubricated reed catheter
- Ancient Greece (341–270 BC) – Epicurus committed suicide for no longer being able to dilate his stricture
- Ancient Rome (25 BC–50 AD) – Cornelius Celsus description of external urethrotomy for treatment of an impacted stone behind a urethral stricture
- Ancient Rome (second Century AD) – Greek-born physician, surgeon and philosopher, Galen settled down in Rome in 162 AD and mentioned urethral dilatation
- Byzantine and Islamic Civilizations – In the tenth century, Rhazes of Baghdad and his contemporaries performed some sort of external urethrotomy or perineal puncture
- 1510–1590: French physician and surgeon, Ambroise Paré revisited urethrotomy and invented an instrument for scraping gonorrhea-associated “carnosities”
- 1765: Scottish surgeon, John Hunter (1728–1793) recommended dilators and caustics for treatment of urethral strictures. The Hunterian Society of London was named in his honor
- 1795: Silver lancelated catheter made its appearance and was the precursor of the later internal urethrotomy
- 1817: Jean Civiale of Paris (1792–1867) produced a practical form of internal urethrotomy
- 1825: English military surgeon, James Guthrie (1785–1856) advocated internal urethrotomy and explored forcible “speedy” urethral dilatation
- 1848: French surgeon, Jules François Maisonneuve (1809–1897) conceived the idea of a filiform guide to facilitate internal urethrotomy
- 1873: Austrian dermatologist, Joseph Grünfeld (1840–1910) performed open urethroscopy with light reflection
- 1870/1875: American Urologist and Professor of Genitourinary Diseases at the New York College of Physicians and Surgeons, Fessenden Nott Otis (1825–c. 1900) described his “urethra-meter” or urethrometer to determine the appropriate caliber of a sound for urethral dilatation; he also produced various mechanical dilators and his two-bladed urethrotomy is still in use today
- 1892: Felix M. Oberländer (1849–1915) designed the first direct vision internal urethrotomy with an incorporated light source
- 1894: Ukrainian Urologist, Kirill M. Sapezhko (1857–1928) first description of OMG urethroplasty
- 1902: Tyrmos used OMG for urethral fistula
- 1941: Humby used OMG in an 8 year-old boy with failed hypospadias
- 1992: Burger and Hohenfellner OMG urethroplasty in dogs and small clinical series
- 1992: Dessanti et al. described use of bladder and OMG for hypospadias
- 1993: El-Kasaby et al. described lower lip OMG harvest
- 1996: Morey and McAninch describe in detail OMG harvest technique and ventral onlay urethroplasty for bulbar strictures

1.6 Modern History of Urethroplasty by Anatomical Segment

1.6.1 Anterior Urethra

1.6.1.1 Penile Urethroplasty

- 1953: Johanson staged urethral repair without grafting
- 1999: Hayes and Malone OMG dorsal inlay technique for hypospadias
- 2001: Asopa one-stage OMG dorsal inlay urethroplasty in adults

1.6.1.2 Bulbar Urethroplasty

- 1996: Barbagli dorsal onlay OMG bulbar urethroplasty
- 1996: Morey and McAninch harvest technique of OMG and OMG ventral onlay urethroplasty
- 1998: Webster augmented dorsal graft anastomosis
- 2006: Barbagli fibrin glue urethroplasty
- 2008: Barbagli bulbospongiosus muscle and nerve sparing bulbar reconstruction

1.6.1.3 Panurethroplasty

- 1953: Johanson two-stage urethroplasty: penile ventral marsupialization followed by second stage retubularization 6 months later
- 1993: McAninch distal/preputial circular fasciocutaneous skin flap
- 2000: Kulkarni penile invagination technique with OMG dorsal onlay
- 2009: Kulkarni one-sided penile invagination technique to preserve lateral neural and blood supply to urethra
- 2010: Barbagli supported perineal urethrotomy with Blandy flap technique for complex/irreparable urethral strictures or unfit patients for surgery

1.6.2 Posterior Urethra

- 1962: Pierce total abdominal pubectomy for exposure of posterior urethra
- 1968: Paine and Coombs end-to-end anastomosis after resection of scar and pubic bone (abdominal approach).

- 1973: Waterhouse combined abdomino-perineal approach.
- 1976: Turner-Warwick use of omentoplasty for transpubic primary anastomosis.
- 1986: Webster and Goldwasser perineal anastomotic urethroplasty with infrapubectomy.
- 2010: Kulkarni and Barbagli etiology and treatment of posterior urethral trauma in India and Italy.

1.7 Conclusion

A long journey has been made from those days in 500 BC when urethral strictures were dilated blindly and difficult cases of retention were abandoned to their own fate/destiny to the present time, when this disease is better understood and largely under control with effective and safe therapeutic (both minimally invasive and open surgical) options.

The traditional treatment of urethral stricture disease has been urethral dilatation and urethrotomy for centuries. The latter is currently performed under visual control, which is a recent development that stemmed from the old “blind” variant. With no clear advantage of one over the other, neither dilatation nor urethrotomy are considered curative by most experienced authors and once started on either, the unfortunate patient with urethral stricture is condemned to such treatment for life.

Management of urethral stricture patients has evolved significantly over the last century. The use of oral mucosal grafts is still one the greatest advancements in urethral stricture management. As we continue to better understand the pathophysiology of urethral strictures, we hope to make even greater strides over the next decade in prevention and management of urethral strictures. Tissue engineering is an exciting new frontier for research in management of urethral stricture disease. Contemporary advances in graft applications such as liquid buccal mucosa, stromal growth factors and stem cell cultures have been utilized to halt the process of fibrosis and to prevent stricture re-formation. These measures may pave the way for revolutionary changes in our routine practice regarding urethral stricture management in the future.

Key Summary Points

- Urethral stricture is probably as old as mankind and has always been a prevalent and challenging urological condition. History of urethral stricture management dates back to ancient human civilizations with the earliest recorded attempts to deal with urethral strictures occurring in India about the sixth century B.C.
- Until the Middle Ages, the treatment of genitourinary problems in general, and urethral strictures in particular was regarded as unworthy of physicians' efforts and was left in the hands of itinerant quacks and charlatans with vague ideas on the subject.
- From the eleventh to the fifteenth centuries medicine and surgery were mostly dominated by religious superstitions and witchcraft which produced an almost completely sterile period in the advancement of urethral stricture management.
- Since the outbreak of epidemic gonorrhea in 1520 AD, urethral stricture began to be regarded as due to obstructing growths, and not to a constriction, in the urethral lumen, an idea that persisted until the eighteenth century, and treatment was mainly forcible urethral dilatation.
- Internal urethrotomy was introduced in the late eighteenth century in the form of catheters with concealed lancets, and in nineteenth century a modification of the procedure being executed from within outwards was invented. James Guthrie, Jacques-Gilles Maisonneuve and Fessenden Nott Otis pioneered of major improvements of internal blind urethrotomy.
- Kirill Mikhailovich Sapezhko (1857–1928), from Chernigov, Ukraine, is credited as the first to use an oral mucosal graft to augment a strictured urethra in 1894.
- Modern urethroplasty surgery is considered to be standing largely on the shoulders of pioneering giants, such as Dennis Brown, Hamilton Russel, Bengt Johanson, Charles Devine, John Blandy and Richard Turner-Warwick.
- Over the second half of the twentieth century, urethral reconstruction has shifted from mainly two-stage procedures to the use of grafts, then onto flaps, and currently back to mucosal grafts, especially oral (cheek, lip and tongue) grafts.
- Since 1962, great advances have been made (and are still ongoing) in the surgical treatment of trauma-related posterior urethral injuries spanning from total abdominal pubectomy better exposure, combined abdomino-perineal approach, use of omentoplasty for transpubic primary reconstruction to the today commonly used four-step elaborated perineal anastomotic urethroplasty.

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Functional Anatomy of the Male Urethra for the Reconstructive Surgeon

2

James Furr and Joel Gelman

2.1 Introduction

The male urethra is a fibromuscular tube that extends from the bladder to the end of the penis. Functionally, the urethra's role is fairly simple in that it allows for transport of urine and semen from the bladder and ejaculatory ducts through the penis. However, certain disease processes can cause scarring within the urethra that result in obstruction of urine flow. The success of surgery to treat urethral strictures is often predicated on the intimate understanding of the male urethra and its transitions along the normal anatomic course. Here, we briefly outline embryology and the normal anatomy of the male urethra, as well as discuss how clinical evaluation and intervention are dictated by anatomic considerations.

2.2 Embryology

While the early development of the external genitalia is similar in both sexes, there are key steps within the process that allow for the formation of the more elongated male urethra. During the

sixth week of development, the cloacal folds that formed the genital tubercle begins to elongate in the male. During the elongation process, a groove forms along the ventral aspect, referred to as the urethral groove. The urethral groove is flanked on each side by the urethral folds, which are simply extensions of the cloacal folds. At approximately 10 weeks, the urethral groove canalizes as it extends towards the glans. Following this step, the urethral folds fuse resulting in the normal formation of the penile urethra. At the most distal tip of the genital tubercle is an epithelial tag that invaginates and fuses with the canalized urethral groove. This will result in the appropriate formation of the fossa navicularis and meatus [1, 2]. Fusion of the urethral folds is typically present at the time of birth. However, failure of the fusion of the penile urethral folds from weeks 11 to 16 results in hypospadias with the urethral opening proximal to the typical location within the glans. Furthermore, the failure of the fusion also results in excess preputial skin dorsally with absent ventral tissue [3, 4]. This scenario results in the lack of complete corpus spongiosum development. Ventral tethering can also be due to the lack of adequate ventral tissue resulting in chordee.

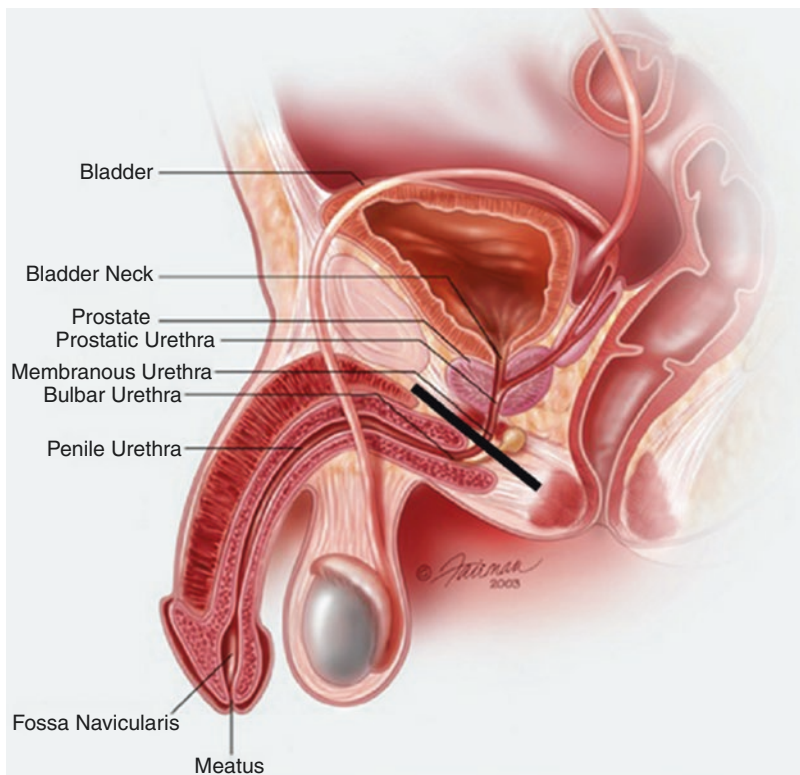
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2.3 Male Urethra: Summary

The male urethra is differentiated into posterior and anterior components. The posterior urethra is subdivided into the prostatic and membranous

Fig. 2.1 Sagittal view of the course of the male urethra. The bold line clearly delineates the transition point from anterior to posterior urethra



urethra. The anterior urethra is subdivided into the bulbar, penile urethra, fossa navicularis, glandular urethra, and terminates at the urethral meatus at the tip of the penis (Fig. 2.1). The normal lumen of the fossa navicularis measures approximately 22–24 fr, while the remainder of the urethra should be at least 30 fr. Narrowing from this should be considered abnormal, but is not necessarily flow limiting especially when the caliber is greater than 16 fr. Histologically, the prostatic urethra is lined with urothelial cell epithelium, while in the membranous urethra there is a transition from urothelial cell epithelium to pseudostratified/stratified columnar epithelium. The bulbar and penile urethra is lined with pseudostratified or stratified columnar epithelium. The fossa navicularis and meatus are lined with stratified squamous epithelium (Fig. 2.2). The location of any injury or stricture has significant implications on the appropriate surgical planning.

2.4 Posterior Urethra

2.4.1 Prostatic Urethra

As the bladder neck funnels into the posterior urethra, it passes through the transition zone of the prostate. There is a functionally distinct delineation between the pre-prostatic and post-prostatic urethra, which also has anatomic implications. For example, within the pre-prostatic urethra, the involuntary circular smooth muscle is thickened and forms the internal urethral sphincter. Just distal to the prostate, the ejaculatory ducts as well as the ducts from the peripheral zone of the prostate empty into the posterolateral portion of the urethra. In between the two orifices of the ejaculatory ducts lies the entrance to the prostatic utricle. The prostatic utricle is an approximately 6 mm Mullerian remnant that can be significantly dilated in patients with history of severe

Fig. 2.2 Histologic differentiation of the urethra as it courses from the bladder to the meatus

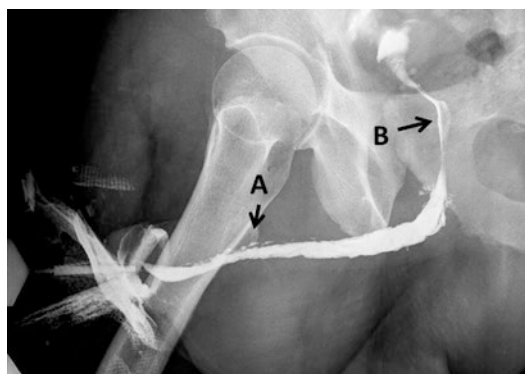
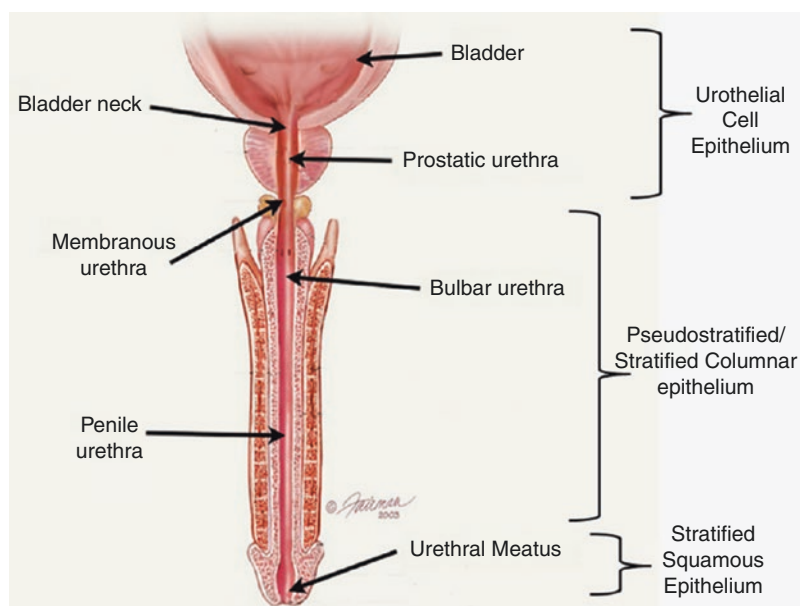


Fig. 2.3 Retrograde urethrogram in patient with panurethral stricture disease and high-grade obstruction. Note the dilation of both the glands of Littre within the penile and bulbar urethra (A) and the filling defect caused by a normal verumontanum (B)

hypospadias or ambiguous genitalia. The utricle as well as the orifices of the ejaculatory duct enters at the verumontanum, with the utricle typically located at the apex. The verumontanum serves as an important anatomic marker of the prostatic urethra, as it can be easily visualized cystoscopically or as a filling defect on adequate urethrography (Fig. 2.3).

2.4.2 Membranous Urethra

The urethra courses through the urogenital diaphragm after leaving the prostate. This comprises the membranous urethra, which is approximately 2 cm in length [5]. The muscular fibers that arise at the junction of the inferior pubic rami encompass this portion of the urethra and make up with striated, voluntary sphincter. The external sphincter lies within the hiatus of the pelvic diaphragm [6–8].

Anatomy studies have revealed that the sphincter is longer anteriorly and the fibers do not meet posteriorly. It is also within this segment of the urethra where the puboprostatic ligaments extend and attach posteriorly, and the suspensory ligaments that attaches the urethra to the pubic bone anteriorly. Due to the close proximity and intimate attachment to the pubis, the prostatomembranous urethra classically was felt to be most at risk for distraction injury following pelvic trauma. However, in an autopsy review of men following distraction injuries performed by Mouraviev and Santucci, the injury was found to occur just distal to the membranous urethra in seven out of the 10 men [9].

2.5 Anterior Urethra

2.5.1 Bulbar Urethra

The anatomic borders of the bulbar urethra are the urogenital diaphragm proximally and the penoscrotal junction distally. It is the second longest portion of the urethra, located within the bulbospongiosus muscle. The bulbospongiosus muscle has a role in expelling urine and seminal fluid that settles within the bulbar urethra. During reconstruction within the bulbar urethra, this muscle is split, and men may experience post-void dribbling and less forceful ejaculations. However, bulbospongiosus muscle sparing techniques have not shown to improve post-void dribbling and ejaculatory outcomes [10]. Only soft tissue and skin surrounds the bulbar urethra anteriorly and the pubic bone posteriorly. As such, the bulbar urethra is not well protected and is at risk of straddle injury in that the bulbar urethra can be crushed against the pubic bone during trauma. Less severe injuries strictures will present in a delayed fashion, many times years after the initial insult. For more major straddle injuries, the presentation can be much more acute.

The bulbourethral (Cowper's) glands, which lie within the urogenital diaphragm, open into the proximal bulbar urethra and can be visualized at times during retrograde or antegrade urethrography (Fig. 2.4). The glands of Littre secrete mucous, and can be seen cystoscopically within the walls of the bulbar urethra. The glands also extend distally into the penile urethra. In obstruc-

tive processes within the urethra, such as Lichen Sclerosus, also known as Balanitis Xerotica Obliterans, elevated urethral pressure can result in dilation of the glands of Littre. This dilation can also often be visualized on retrograde urethrography (Fig. 2.3).

2.5.2 Penile Urethra, Fossa Navicularis, and Meatus

The entire length of the penile urethra is surrounded with the corpus spongiosum. The corpus spongiosum at the level of the penile urethra is fixed dorsally to the corpus cavernosum. Laterally within the walls of the penile urethra multiple recesses can be visualized cystoscopically called the lacunae of Morgagni, which terminate with the glands of Littre. The penile urethra terminates as it enters the glans penis. Within the glans, the urethral segment is referred to as the fossa navicularis, which terminates at the urethral meatus. The fossa navicularis is completely surrounded by the spongiosal tissue at the coronal margin, and is no longer fixed to the corpus cavernosum as the corporal bodies do not enter the glans penis. Understanding this anatomic distinction between the fossa navicularis and the rest of the urethra is an important concept, as stricture etiology within the fossa is often also distinct. Hypospadias results in the ventral and proximal displacement of the urethral meatus proximal to the glans penis. Unlike other anterior urethral strictures that are most often from trauma or idiopathic, strictures within the fossa navicularis are more often iatrogenic from prior instrumentation or lichen sclerosus, also known as balanitis xerotica obliterans [11, 12].



Fig. 2.4 Retrograde urethrogram view of flow into Cowper's glands (A)

2.6 Urethral Blood Supply

2.6.1 Arterial Blood Supply

The urethra and associated corpus spongiosum has two major sources of arterial blood supply allowing for extensive dissection, mobilization and division without causing ischemic change.



Fig. 2.5 The dual blood supply to the urethra

The urethra and spongiosum receive blood supply in both an antegrade and retrograde fashion. Arterial inflow to supply the urethra and the spongiosum comes primarily from the bulbar and dorsal arteries. These branches originate from the common penile artery, a continuation of the internal pudendal artery. The common penile artery then branches into the bulbar, urethral, and dorsal arteries. Collectively, the bulbar arteries provide antegrade flow to the urethra and corpus spongiosum, and the dorsal arteries provide blood to the glans. Since the glans is in continuity with the rest of the corpus spongiosum, the dorsal arteries provide the additional retrograde blood supply to supplement the antegrade flow from the bulbar arteries (Fig. 2.5). There is also a minor component of perforating vessels between the corporal bodies and corpus spongiosum.

Within the spongy tissue of the corpus spongiosum are distinct urethral arteries. The distribution of the urethral arteries around the urethra is not consistent between individuals, nor is the number of the urethral arteries. Most individuals have between two and three urethral arteries which are located anywhere around the circumference of the urethra, not simply the classic three and nine o'clock positions [13]. Despite such findings, the specific location of distinct urethral arteries is of limited clinical significance when performing open reconstruction. While several urethral arteries are described in anatomic studies, these specific arteries are generally not encountered when the spongiosum is transected. The corpus spongiosum in its entirety is a highly vascular tissue that can bleed when entered, regardless of the distinct location of urethral arteries. In the glans and fossa navicularis, the corpus spongiosum is more robust and the urethra

is surrounded completely by the spongy tissue of the glans penis. In the penile urethra, the dorsal and ventral aspects of the corpus spongiosum have similar caliber, whereas more proximally in the bulbar urethra, the corpus spongiosum becomes more robust ventrally.

2.6.2 Venous Blood Supply

A venous plexus lies within the spongy glans, the most distal aspect. This plexus coalesces with three primary venous branches. The periurethral vein runs within the corpus spongiosum and arborizes with the deep dorsal vein via multiple circumflex veins that branch around the corpus cavernosum. As these veins travel more proximally, they converge at Santorini's plexus just proximal to the pubic bone, adjacent to the prostate on each side.

2.7 Clinical Considerations

Initial evaluation of the urethra is typically performed via cystoscopy and retrograde urethrography. For such procedures, the meatus gives urethral access for imaging and evaluation. When performing retrograde urethrograms with the aid of a Foley catheter, the balloon is often inflated to create a seal. The authors have measured the French size of the catheter balloon, and observed that inflation of only 2 cc results in a 50 fr expansion, which can dilate and damage the fossa that is only 22–24 fr (Fig. 2.6) in size. Moreover, there is data to suggest that even placement of a 22 fr catheter increases the risk of development of fossa navicularis strictures [11].

Another important anatomic consideration prior to surgical intervention is the status of the bladder neck and membranous urethra as it relates to continence. In the normal male, both the bladder neck and the membranous urethra contribute to continence. One of the two mechanisms must be intact in order to maintain continence. For instance, following radical prostatectomy the bladder neck no longer contributes to continence, but men regain their

Fig. 2.6 Demonstration that each additional volume placed into a Foley balloon results in increased French dilation

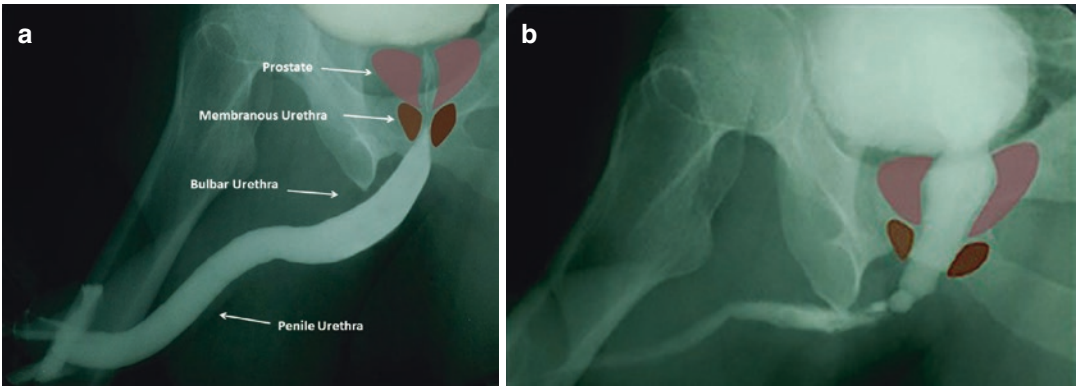
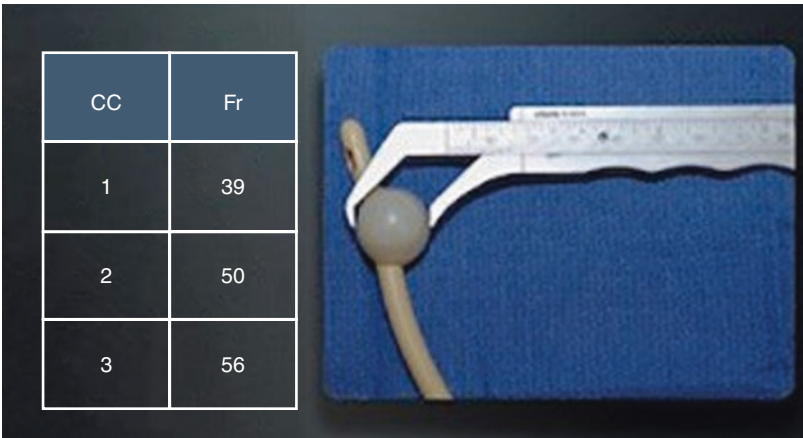


Fig. 2.7 Retrograde urethrogram with closed membranous sphincter and bladder neck at rest (a), indicating both continence mechanisms are intact. On voiding cysto-

urethrogram, note that both the bladder neck and membranous urethra open (b)

continence if the membranous sphincter has not been permanently violated from the operation. Alternatively, if the membranous urethra is damaged from radiation, trauma, or surgery, then an intact bladder neck is required to maintain continence following repair. On anatomic evaluation with retrograde urethrogram, the bladder neck and membranous urethra is typically closed and narrow due to normal sphincter function (Fig. 2.7a) and opens on a voiding urethrogram (Fig. 2.7b). In patients with membranous strictures, it is imperative to evaluate the integrity of the bladder neck, as it will be the only continence mechanism following reconstruction in the membranous urethra. However, an intact bladder neck would suggest that continence could be preserved following reconstruction of the membranous urethra.

In patients who have previous history of hypospadias, trauma or prior urethral surgery, the dual supply to the urethra is often violated. As such, subsequent repairs place the urethra at risk of ischemia if the remaining blood supply is not preserved. For example, in patients with hypospadias repair, there is impaired retrograde flow and the patients are more dependent on antegrade supply via the bulbar arteries. Moreover, the concept of increased risk in patients with impaired retrograde supply is further supported by a report describing patients with a history of hypospadias repair who then underwent urethral stent placement to treat a short bulbar stricture and then developed ischemic pan-urethral stricture disease [14]. No definitive reports have indicated that disruption of such retrograde flow results in poor long-term

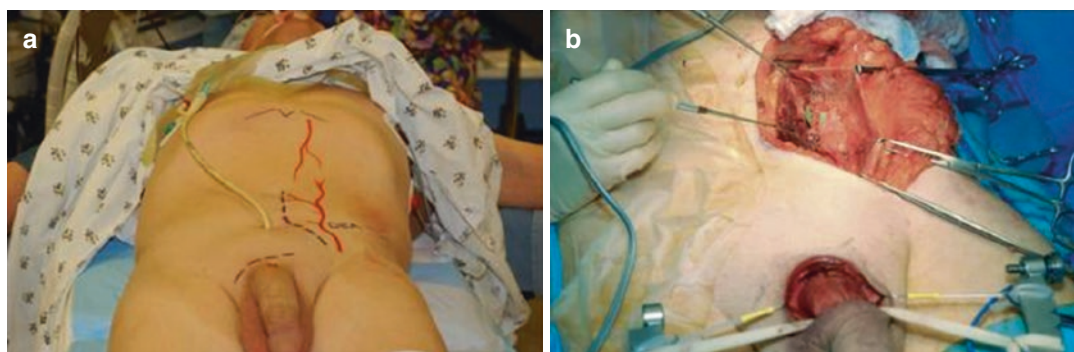


Fig. 2.8 Interior epigastric artery to dorsal penile revascularization, shown after skin marking (a) and intraoperatively (b). (From Gelman and Wisenbaugh [18])

outcomes. However, basic reconstructive principles imply that the preservation of blood supply should be of particular importance in at risk patients, such as those with hypospadias, vascular disease, prior urethroplasty. Consequently, in this patient population strict preservation of blood supply is suggested, with a non-transecting or two layer, bulbar artery sparing approach that would allow for better reconstitution of the spongiosal tissue [15, 16].

Patients with previous pelvic fractures also result in a unique challenge as the initial injury often compromises the deep internal pudendal blood flow. Posterior urethral reconstruction generally includes transection of the urethra at the most proximal bulbar portion, which is associated with transection of the bulbar arteries. In general, this is not problematic given the additional retrograde blood supply via the dorsal arteries along with a contribution of perforating vessels. However, if there is compromise to both dorsal arteries as a consequence of arterial injury associated with pelvic fracture trauma, this may be associated with a risk of ischemic urethral stenosis following urethral transection during urethroplasty. Jordan et al. found that patients most at risk for failure of posterior repair following pelvic trauma were those with decreased glans sensation, erectile dysfunction, children, and the elderly. As such, penile revascularization with inferior epigastric artery to dorsal penile artery anastomosis in patients with compromised dorsal artery vasculature bilaterally on pudendal angiography

should be considered prior to urethral reconstruction (Fig. 2.8) [17].

When synchronous strictures exist within the urethra, preservation of blood supply when repairing the proximal bulbar stricture is especially important as the retrograde supply may be compromised from the distal pathology or repair. While little data exists on the topic of synchronous strictures, anatomic and reconstructive principles suggest that special attention should be given to not compromise both blood supplies or a dependent vasculature during the repair. In this situation, a non-transecting or bulbar artery sparing approach with two layer closure for the proximal stricture would theoretically be advantageous, as it would preserve antegrade blood supply.

2.8 Conclusion

An appropriately functioning male urethra allows for the antegrade flow of urine and semen without obstruction. We outline various scenarios that can result in a disruption of typical urethral anatomy and blood flow. Although the male urethra has redundancy of blood supply, congenital disorders such as hypospadias, prior urethral surgery and trauma can limit the blood supply. An understanding of both normal and abnormal urethral anatomy has direct implications on surgical planning and outcomes. In complex cases, preservation of adequate blood supply affects overall success and can prevent ischemic stricture recurrence.

Key Summary Points

- The lumen of the urethra should be at least 30 fr. with slight narrowing to 22–24 fr at the fossa navicularis. Narrowing from this should be considered abnormal, but is not necessarily flow limiting especially when the caliber is greater than 16 fr.
- The posterior urethra includes to prostatic urethra and membranous urethra. The membranous urethra encompasses the external sphincter, which contributes to continence in addition to the sphincteric bladder neck.
- The bulbar urethra is not well protected and is at risk of straddle injury
- The normal urethra has dual arterial blood supply which includes paired bulbar arteries that enter the proximal bulbar urethra, and paired dorsal arteries of the penis which supply the glans and provide retrograde flow to the corpus spongiosum.
- Patients who have previous history of hypospadias, trauma or prior urethral surgery, the dual supply to the urethra is often violated, which can have direct implications on surgical planning and outcomes.

Conflicts of Interest There are no conflicts of interest.

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Etiology, Epidemiology, Demographic Differences in Urethral Strictures: A Worldwide Perspective

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3.1 Incidence of Urethral Stricture

The true incidence of urethral stricture worldwide remains largely unknown, due to the difference in etiologic factors, the epidemiological variation across the globe, and the scarcity of published epidemiological studies. Santucci et al. in 2006 analyzed the services for urethral stricture disease in ten public and private data sets in the United States. They showed that the prevalence of urethral stricture disease ranged from 229 to 627/100,000 males, with the propensity to affect males who are over 55 years of age. Data for Medicare and Medicaid services demonstrated that in 2001, 9/100,000 men who are over 65 years of age were affected with the disease compared those who are less than 55 years of age (5.8/100,000). Urethral stricture outpatient visits for Medicare patients were 21/100,000 in 2001, which is half the number of patients with renal stones in the same age group.

Procedures for urethral stricture are still commonly performed. While urethral dilation procedures were reduced by half in 2001 (19,658/100,000) compared to 1992, the procedure remains prevalent, at double the rate of ureteroscopy. Healthcare Cost and Utilization Project data reported a hospitalization rate of 3.8/100,000 in 2000, which is a reduction of nearly 50% compared to 1994. This reduction could be attributed to a declining incidence of the disease or to more successful treatment options available. Thee data also showed that Black Americans were more likely to be affected with the disease compared to White Americans. Data for Asians, Hispanics, and Native Americans were not enough to draw conclusions [1].

Stein et al. examined retrospectively 2589 patients from the United States, Italy, and India. They found that the mean age for stricture disease was 41.4 years, and patients from the US and Italy were more likely to have penile urethral stricture compared to Indian patients who were more likely to have posterior urethral stricture and were more likely to have Lichen Sclerosus [2]. Palminteri et al. investigated 1439 patients from Italy [3]. The mean age for stricture presentation was 45.1 years (range 2–84 years), with a mean stricture length of 4.2 cm. Of those strictures, 92.2% were located in the anterior urethra (46.9% in the bulbar urethra). Patients with bulbar urethral stricture were noted to be younger in age. They also noted that 73.6% of patients had prior surgical intervention before presenting to the tertiary care center [4].

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On the other hand, Barbagli et al. from Italy evaluated patients with pelvic fracture urethral injury (PFUI) and found that 15% of PFUI were children, while 85% were adults [5]. Kulkarni et al. examined PFUI from India and Italy and showed that in India 9.4% were children and 16.2% were adolescents compared to 1.5% children and 6.5% adolescents in Italy [6]. Pratap et al. examined PFUI patients in Nepal and found that 48% were prepubescent boys [7]. Their results were similar to Zhang et al. [8] results in China and Koraitim results in Egypt [9].

3.2 Etiology of Urethral Stricture

Before exploring the etiology of the urethral stricture it is crucial to explain certain terminology that highly correlates to the underlying pathophysiological abnormality. In 2010, the International Consultation on Urological Diseases (ICUD/SIU) adopted standard terminology related to urethral disease.

According to the committee, urethral stricture is defined as an abnormal narrowing of any segment of the urethra surrounded by corpus spongiosum. It is often associated with varying degrees of spongiofibrosis. Therefore, the term “stricture” should anatomically be reserved for the anterior urethra.

Diversely, the term “stenosis” is anatomically confined to the posterior portion of the urethra that is not surrounded by corpus spongiosum. The committee described “stenosis” as narrowing of the membranous urethra not secondary to pelvic fracture urethral injury (PFUI), the prostatic urethra, or the bladder neck.

In the year 1993, the term pelvic fracture urethral distraction defects (PFUDD) was adopted by Turner-Warwick [9]. He assumed that the vast majority of these injuries were complete. However, the international committee have replaced the term PFUDD by PFUI. The committee concluded that such injuries are not usually complete, and even if they are complete, they might not be distracted. Moreover, the terminology “PFUI” may include injury to the proximal bulbar urethra too.

3.2.1 Anterior Urethra

During the past four decades, various studies have highlighted the etiology of anterior urethral stricture. Of 175 patients diagnosed with anterior urethral stricture in Texas and Honduras, the bulbar urethra was the most common site for stricture [10]. Anterior urethral stricture can be due to iatrogenic, traumatic, inflammatory, infectious or idiopathic causes.

A review of 20 articles (from 1961 to 1981) found that the incidence of urethritis was 40% among all cases of anterior urethral stricture [11]. Nevertheless, most contemporary studies recognized a dramatic change toward idiopathic and iatrogenic causes.

The normal epithelium of the anterior urethra is lined by pseudostratified columnar epithelium, which is enclosed by a connective tissue layer [12]. This connective tissue consists of vascular sinusoids of the corpus spongiosum along with smooth muscle fibers.

The connective tissue exhibit abundant amount of fibroblasts, and an extracellular matrix (ECM) which is composed of collagen. As reported by immunohistochemical examination of collagen within the normal urethra, types I, III and IV collagen were the most predominant types [13]. Unlike Type IV collagen, types I and III collagen is distributed throughout the spongiosum, while type IV collagen is located only at the basement membrane of the sinusoidal and vascular spaces.

Although the exact mechanism of urethral stricture remains unknown, it seems that squamous metaplasia of normal urethral epithelium is the initial pathological change. With further metaplastic tissue insult, urinary extravasation develops, which in turn results in spongiofibrosis and narrowing of the urethral lumen. Immunohistochemical evaluation of spongiosum tissue of the strictured urethra revealed a decrease in the ratio of type III to type I collagen. Moreover, Cavalcanti et al. [14] demonstrated a reduction in the ratio of smooth muscle to collagen with significant changes in the synthesis of nitric oxide.

3.2.1.1 Infectious Stricture

The issue of infectious strictures is becoming more controversial and a much disputed subject

in spite of the advancements of antibiotic therapy. A group from Brazil demonstrated that infectious strictures account for only 15.2% of cases [15]. Nonetheless, Stein et al. found no significant difference in the prevalence of infectious stricture among developed and developing countries (0.8 vs. 1.8%). Infectious strictures are most commonly secondary to gonococcal urethritis. The average period of incubation for stricture formation following gonococcal infection appears to be between 18 and 20 years [16].

Abscess formation in the glands of Littre is the cornerstone of stricture development. As a consequence of abscess eruption into the corpus spongiosum, inflammation occurs and consequently lumen stenosis and spongiofibrosis develop. The vast majority of paraurethral glands are concentrated in the bulbar urethra. Moreover, a scanty amount of the paraurethral glands have been found to be in the penoscrotal junction as well as just behind the meatus.

Notwithstanding the constant urethral exposure to the urinary bacilli, urethral tuberculosis occurs in only 1.9–4.5% of all cases of urogenital tuberculosis [17]. Primary disease is considered to be a rare presentation, with the majority of cases being secondary to prostate tuberculosis. It can be clinically suspected in those with long strictures, particularly if fistulas, periurethral abscesses or tuberculous prostatitis is evident (Fig. 3.1).



Fig. 3.1 A 70 year old male patient presented with urethral stricture associated with periurethral abscess. Perineal urethrostomy was performed. (Copyright to Faisal Alhajeri)

3.2.1.2 Lichen Sclerosus

Lichen sclerosus (LSc) is a chronic inflammatory skin disease, with a higher tendency for the anogenital area. Stuhmer was the first to describe a male form of LSc in 1928. Microscopically, it is characterized by hyperkeratosis of squamous epithelium, epidermal thinning, loss of rete pegs with collagen deposition of the collagen in the upper third of the dermis, and lymphocytic or plasmacytic infiltration.

Nowadays, the most common cause for inflammatory strictures in western countries is LSc. The true prevalence and incidence of male urethral Lichen sclerosus (LS) Lichen sclerosus urethral stricture disease (LSUSD) remains unknown. Palminteri et al. reported 13.4% of Italian patients suffering from anterior urethral strictures were secondary to LSc. It has accounted as etiology in 48.6% of long panurethral strictures [18]. Additionally, the second cause (24.4%) of penile strictures after hypospadias repair was LSc. Barbagli et al. [19] also reported a high incidence of LSc in patients with failed hypospadias repair. Interestingly, the prevalence of LSc was significantly higher in developing than developed countries.

Several studies attempt to determine the premalignant role of LSc as well as the relationship to penile squamous cell carcinoma (pSCC). Male genitalia lichen sclerosus (MGLSc) were found in 28% of 155 patients with penile carcinoma. On the other hand, other researchers could not confirm the premalignant role of LSc.

It often originates at the prepuce and glans, and is rarely seen in a circumcised male at birth. This indicates that the foreskin must play a significant part in the pathogenesis of LSc. Variable clinical presentation of MGLSc have been previously demonstrated. Riddell et al. [20] noted that tight foreskin was the common clinical presentation of MGLSc (Fig. 3.2).

The involvement of the external urinary meatus and navicularis tract may contribute to the embryology of the glans. Because of the embryologic origin of the glans along with the fusion of preputial folds to the genitals folds during the development of the glanular urethra, skin diseases may involve the glanular urethral mucosa.



Fig. 3.2 Tight foreskin as presentation of LSc. (Copyright to Faisal Alhajeri)

As the disease progresses, it can cause destructive genitourinary scarring resulting in urethral stricture. Distal urethral involvement (LSUSD) is typically secondary to a slow proximal progression from the glans and/or meatal LSc. LSUSD tend to be significantly longer than those from the other etiologies.

Barbagli et al. [21] found positive meatal biopsies for LSc in about 91% of all male patient with urethral stricture. Unlike the distal segments of the anterior urethra, bulbar urethral biopsies for LSc were negative despite radiological evidence of a panurethral stricture. Some authors attribute the presence of a proximal urethral stricture in some patients to iatrogenic trauma. On the other hand, Liu et al. [22] reported a significant incidence of LSc in isolated bulbar strictures with no evidence of distal involvement.

3.2.1.3 Traumatic Strictures

The anterior urethra is more vulnerable to blunt rather than penetrating trauma. The most frequently injured anterior urethral segment is the proximal bulbar urethra. Typically, it is caused by straddle type injury, where the immobile bulbar urethra is compressed against the inferior pubic rami. Falling astride was found to be the most common cause of straddle injury.

In some instances, the injury might be clinically unrecognized at early presentation, however, later on the patient might developed symptoms of urethral stricture which was dis-

played by Park and McAninch [23]. They reported that 60% may present with symptoms of urethral stricture 6 months to 10 years from the onset of acute injury. Most often, it is a short stricture. It is rarely associated with serious organ trauma. According to a meta-analysis of anterior urethral stricture, the traumatic stricture represents only 19% of all cases (insert reference). A more recent study from Italy found that external trauma to the anterior urethra comprised only 5.6% of all cases.

3.2.1.4 Iatrogenic Strictures

Iatrogenic urethral stricture is a result of ischemic insult from either urethral instrumentation or catheterization. As mentioned previously, there is a tremendous increase in the prevalence of iatrogenic urethral strictures in western countries. Interestingly, the causes of iatrogenic strictures are different among age groups. Some authors identified transurethral resection as the main cause of iatrogenic stricture in those above 50 years. On the other hand, hypospadias surgery is done mainly in younger patients. The stricture occurs at the point of urethral fixation or lumen narrowness, namely; the bulbomembranous urethra, penoscrotal junction, and the fossa-meatus.

Most post-instrumentation strictures tend to be short. It is mainly located at the bulbomembranous urethra. Unlike the post-instrumentation type, post-catheterization strictures are found to be long and irregular, and commonly occur at the penoscrotal junction. Mathur et al. [15] reported 60% of post instrumentation strictures at the membranous and bulbar urethra. Moreover, 48% of post catheterization strictures were located at the penoscrotal junction.

Post-catheterization stricture can be either from prolonged catheterization or inappropriate catheter insertion. An up to date report estimated that 3.2 urethral injuries per 1000 inpatients occurred due to improper urethral catheterization. Urethral inflammation and ischemia from prolonged catheterization may lead to urethral stricture. Some researchers have linked prolonged catheterization urethral stricture to the catheter material itself. Comparing silicon to latex catheters, the former is associated with min-

imal urethral reaction and irritation. Moreover, the inevitable movement of the catheter within the urethra might play an important role in urethral irritation too. It has been advised, if prolonged catheterization is required; to replace transurethral with suprapubic catheters.

Generally, urethral catheterization is considered as one of the most common iatrogenic causes of penile urethral stricture, and panurethral or multifocal anterior stricture. Palminteri et al. found that catheterization was the third common cause of penile and panurethral stricture (16.2% and 16.3%), and the second common cause of bulbar urethral stricture (17.3%). Some authors have connected catheterization to multifocal anterior strictures as a main cause. However, some will argue the association since most of those patients have underwent repetitive minimally invasive urethral procedures.

It has been documented that the prevalence of urethral stricture following transurethral resection of the prostate ranges from 2.2% to 9.8% [24]. However, the exact pathophysiology remains unclear. Some have contributed the stricture formation to improper traumatic insertion of the resectoscope with perforation of the bulbous urethra and instrument friction at the penoscrotal angle. This might be provoked by the narrow urethral caliber as well as monopolar current leak. Endoscopic evaluation of the urethra several days post-resection revealed isolated erythematous areas in the urethral mucosa.

Urethral stricture has been documented as a late complication of radiation therapy for prostate cancer. Generally, radiation induces an obliterative endarteritis which in turn compromises the vascularity of the urethra. This affects the fibroblast's capability of producing collagen and compromises the collagen maturation leading to contraction and spongiofibrosis. Certain risk factors have been significantly linked to the incidence of urethral stricture including the radiation dosage and the type of radiation used. Elliott et al. investigated the incidence of stricture of different radiation therapy modalities. He reported the incidence of stricture from brachytherapy (BT) to be 1.8%, external beam radiation therapy (EBRT) 1.7%, combined EBRT and BT 5.2%,

and cryotherapy as 2.5% [25]. The majority of reported strictures after radiotherapy are located in the bulbomembranous urethra.

3.2.1.5 Idiopathic Strictures

Surprisingly, the prevalence of idiopathic urethral stricture (IUS) is significantly increased nowadays. From a review of contemporary urethral stricture etiology by Viers et al. [26], IUS was the most frequent (37%) among all causes of anterior urethral stricture. It often presents as a short stricture in the bulbar urethra. The strictures are most commonly seen in a younger age group. Accordingly, some researchers suggested that it can be a late consequence of unrecognized perineal trauma in childhood.

Many idiopathic strictures may develop as a consequence of inadequate canalization, when the part of the urethra derived from the urogenital sinus joins the part derived from the urogenital folds, becoming symptomatic with growth [27].

3.2.2 Posterior Urethra

3.2.2.1 Posterior Urethral Stenosis

Bladder neck contracture (BNC) following radical prostatectomy (RP) is a consequence of impaired epithelial-to-epithelial apposition during the vesico-urethral anastomosis (VUA). Certain mechanisms have been contributed to VUA stricture formation which include anastomotic tension, inflammation from urinary extravasation, poor tissue handling, and ischemia. It occurs in 1.4–29% of patients after RP. BNC rates differ between surgical approaches of RP. The prevalence after open RP is higher than that after perineal prostatectomy as well as after minimally invasive prostatectomy. It has been suggested that the rate of BNC following robotic RP could be between 1% and 3%. However, the rate after salvage RP is higher than after primary RP.

The rate of BNC after radiation have been estimated to be between 2% and 12%. The risk factors for the development of BNC following radiation have been implicated to be similar to that of urethral stricture from radiation. However, more studies are required.

3.2.2.2 Pelvic Fracture Urethral Injury

The incidence of urethral injury from pelvic fracture varies widely, however, it has been estimated to be between 1.54% and 10%. Motor vehicle accidents, occupational accidents, and falls from a large height have been commonly contributed to such injury. There is a significant difference of both prevalence rate and underlying etiology of PFUI among developed and developing countries. Kulkarni et al. [5] found that the etiology beyond PFUI differs between countries of different culture. In India, pedestrian accident was the most common etiology followed by motorcycle and bicycle accidents (35%, 26.5% and 12.8% respectively), whereas car (39.2%) and work site (25.3%) accidents were the most frequent causes in Italy. Recently, published data from Italy reported a significant decline in agricultural accidents. This might explain the significant reduction in the incidence of serious pelvic and urethral distraction injuries.

Tile's classification is the most accepted classification system of pelvic fracture. Two concepts are combined: pelvic ring compression and degrees of instability. The classification divides pelvic fracture into three main categories. Unlike Tile type B and C, pelvic fractures that fall under type A are considered to be stable, which is seldom associated with urethral injury. Certain factors may contribute to increase the risk of urethral involvement, including the number of broken rami and pubic arch fractures. Bilateral fractures of the ischiopubic rami (Straddle fracture) with posterior displacement of bone fragment toward the prostate may result in urethral injury even in a stable pelvic fracture. The highest risk of urethral injury has been found when a straddle fracture is combined with diastasis of the sacroiliac joint, followed by Straddle fracture alone and Malgaigne's fracture.

It has been assumed that it is the shearing force leading to the avulsion of the prostatic apex from the urogenital diaphragm. Based on the previous assumption, urethral ruptures should occur at the level of the prostatomembranous junction (PMJ). Some authors suggested that urinary continence postoperatively depends on the bladder neck itself, hence, the injury jeopardizes the function of

the rhabdosphincter surrounding the membranous urethra. However, recent studies negated such assumption. A recent autopsy study failed to confirm the presence of a definite superior membrane of the urogenital diaphragm which separates the sphincter muscle from the prostate. Another autopsy study determined the preservation of the external urinary sphincter in the majority of PFUI cases. Nowadays, it has been widely accepted that the avulsion injury occurs mainly at the level of the bulbomembranous urethra.

The incidence of female and pediatric PFUI is less than that of males. The infrequent incidence of PFUI among females may be related to certain anatomical factors of the female urethra, including a shorter urethra and lack of its pubic attachment. The estimated incidence of pediatric PFUI is 2.4–7.5% [28]. In contrast to an adult male patient, urethral injury in male pediatric patients tend to be more proximal. This might contribute to an underdeveloped prostate in boys as they might suffer from either bladder neck injury and/or complete urethral disruption.

3.3 Conclusion

The etiology of urethral stricture may vary in industrialized and developing countries. Although the location and length of stricture are considered key in the treatment of any urethral stricture disease, it is important to identify the etiology of such stricture.

Key Summary Points

- Urethral stricture disease is relatively common, and its etiology varies geographically.
- The true incidence of urethral strictures in men remains unknown, and worldwide differences have been observed based on geography, population, and mean country income.
- The incidence of urethral stricture rises sharply in men over 55 years of age in the Western population.

- The etiology differs significantly between younger vs older patients and among stricture sites.
- Generally, perineal trauma, long-term indwelling urethral catheters, urologic instrumentation, chronic inflammatory disorders such as lichen sclerosis, and sexually transmitted diseases are still the predominant causes.
- Iatrogenic and idiopathic etiologies are the main causes of urethral strictures in developed countries, currently accounting for about one half and one third of urethral stricture cases, respectively, whereas, in general, the incidence of infection-related urethral stricture has decreased in this part of the globe.
- Trauma remains the most common etiology of urethral strictures in developing countries.
- The incidence of urethral strictures related to some form of radiation treatment employed in pelvic malignancies has increased steadily, especially in industrialized countries.

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World Changing Scenario of Urethral Stricture Management

4

Kuncoro Adi, Faisal Alhajeri, and Paksi Satyagraha

4.1 Introduction

Urethral stricture has always been common and the management of urethral stricture disease has been dynamically evolving. It is one of the oldest and most difficult diseases known in urology [1]. There was a time when the urology community believed in the precept “once a stricture always a stricture”. However, the current opinion is that stricture disease is curable. The true global incidence of urethral stricture disease can only be vaguely estimated. The incidence and epidemiology of this disease differ worldwide based on geography, population and mean country income. However, in the United Kingdom, more than 12,000 patients per year require surgery because of urethral stricture disease. Meanwhile, in the United States of America, male urethral strictures occur at a rate of 0.6% per year in a susceptible population resulting in more than 5000 inpatient visits per year [2, 3]. In the developed world, the most common etiology for male urethral strictures are now thought to be iatrogenic and idio-

pathic [1, 4, 5]. In developing countries, infection and traumatic urethral strictures are the most prevalent. However, there is significant regional variation in stricture etiology with different patterns noted in other parts of the world. Single-institution studies in a variety of countries have shown varied prevalence of etiologies of urethral stricture [5–10]. Moreover, the differences between the developed and developing countries should be considered (Table 4.1).

The basic management of male urethral stricture consists of urethral dilatation, internal urethrotomy, stenting and open reconstructive surgery. In 1949 Scardino and Hudson published the declaration that urethral dilatation for stricture was “useless”. Most urologists still routinely

Table 4.1 Urethral stricture etiology: DC vs. UDC

UDC
Trauma
Lichen sclerosis
Infection
Iatrogenic
Idiopathic
DC
Idiopathic
Iatrogenic
Trauma
Lichen sclerosis
Infection

Difference in etiology of urethral stricture in developed country (DC) versus undeveloped-developing country (UDC). Listed from the most common etiology based on review in current literature [1–10].

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use internal urethrotomy or dilatation, although evidence shows no definitive satisfactory outcome with this approach. Endoscopic urethral surgery and urethral dilatation can transiently improve urinary flow; however open urethral surgery is now regarded as the gold standard treatment for urethral stricture disease [8, 11–16].

The choice of endourologic surgery or open urethroplasty depends on etiology, location, length and character of the stricture. The initial management of the male urethral stricture has become increasingly debatable. Proper initial management is the best chance to correct the stricture and the failure rate increases with subsequent surgery. Many urologists still believe that there is a “reconstructive ladder” and that treatment should always start at the bottom with dilatation and or internal urethrotomy and work up the ladder to open reconstructive surgery as the last resort. The published data has shown that there is a 50% stricture free rate with internal urethrotomy or dilatation, exclusively in patients who have a single, previously untreated, short, membrane-like stricture of the bulbar urethra [8].

Surgical treatment for urethral stricture disease has been adopted worldwide with significant improvement of outcomes and simultaneously a decrease in complications. Various surgical techniques have been developed in the last 30 years and are being used to repair anterior and posterior urethral stricture or stenosis with the goal of reducing morbidity and obtaining the best outcome with less complications. Since the late 1980s, buccal mucosa grafts have gained popularity as a surgical technique during urethral reconstructive surgery. There are many reconstructive surgical techniques, and no one technique is appropriate for all stricture diseases [15]. The different techniques of surgical intervention are documented and presented in the literature by various authors from different countries. Several factors play a role in the decision of open surgical treatment such as location of the stricture, cause of the stricture, previous urethral surgeries, the quality of the urethral plate, availability of autologous tissue to be used as flaps or grafts, experience, expertise and the preference of the treating urologist [16]. The urethral reconstructive urolo-

gist is requested to be familiar with the use of various techniques to deal with any etiology, location, length and characteristics of the stricture. Proper patient selection and reconstructive techniques will play a role in terms of successful management.

Standardizing urethral stricture evaluation, management and follow-up according to guidelines with grading recommendations will help to improve practice. In 2013, the American Urological Association (AUA) released guidelines written by the Male Urethral Stricture Guideline Panel of the AUA Education and Research, Inc. In 2010, the International Consultation on Urological Disease (ICUD) panel on urethral stricture bringing more consistency to the literature in terms of terminology, definition and specific management recommendations. Strictures can be divided into two main types, anterior and posterior, according to the underlying pathogenesis. Understanding the etiology of urethral strictures plays an important role in deciding on the specific type urethral reconstructive surgery. In the past, urethroplasty was only considered after failure of instrumentation or occurrence of complications. However, medical care has improved and the procedure has become safer [17, 18].

In this chapter, we will discuss the changing landscape of urethral stricture management. An historical perspective will be given as well as a discussion of the present treatment options. Minimal invasive therapies including urethral dilatation, urethral stenting, internal urethrotomy and other endoscopic options are making way for open urethral reconstructive surgeries due to its curative intention. The role of urethrotomy and other minimally invasive interventions in the management of urethral stricture disease will also be discussed.

4.2 Historical Perspective

Urethral stricture disease is as old as human civilization. It is one of the oldest known urological diseases. Reports have been documented in ancient Hindu, Egyptian and Greek literature. In ancient India, Sushruta described in Ayurveda

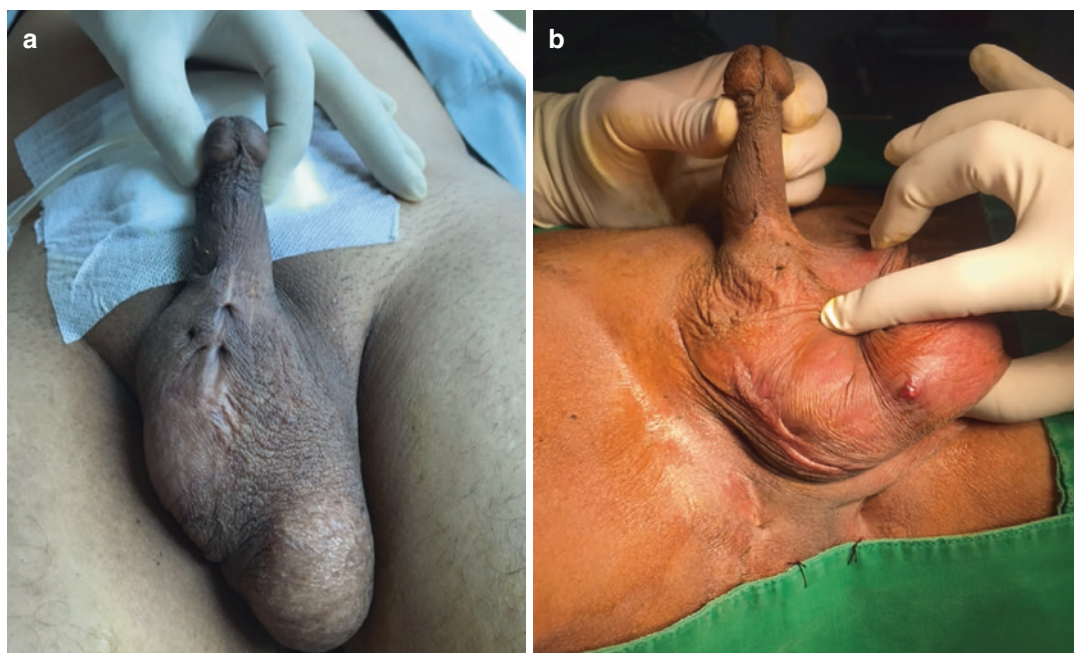


Fig. 4.1 Urethrocutaneous fistula. Three fistulae (a) and nine fistulae (b)

(the traditional Hindu system of medicine) the use of graduated dilators made of metal or wood. Urethral dilators were mentioned in 3000 BC in the ancient Egyptian tombs of pharaohs to dilate the strictures in the after life. This demonstrates that having an urethral stricture meant having it for life, as well as in the after life [15, 19].

In ancient times, when dilatation and urethrotomy could not be done, there were three possible outcomes: the first was to hope for fistula development. The other possibility was to do blind external urethrotomy into the perineum until the normal proximal urethra was found, or urinary diversion transpubically or transrectally. Simple blind dilatation to disrupt and widen the scarred area has been practiced for many centuries. Metal (Clutton's or Buckston Broene's) dilators, gum elastic (Harrison's whip), or plastic rods were used to increase the diameter of the urethra, usually about eight millimeters in diameter. The traditional method for management of urethral stricture was periodic dilatation, but this could lead to further damage to the urethra increasing the degree of scarring. Obliterated strictures complicated by abscesses and fistulae were

sometimes relieved by external urethrotomy proximal to the stricture, but for many patients the only possible management was urinary diversion by performing suprapubic cystostomy [15, 20] (Fig. 4.1).

The pioneering development of urethroplasty started in the 1950s and 1960s. Since then, there have been two basic principles of surgical treatment, anastomotic urethroplasty for short strictures and substitution urethroplasty for long strictures. In 1953, Johanson applied Denis Browne's buried skin strip technique to adult male strictures. Surgeons all around the world adopted this new two-stage urethroplasty. It was successful in relieving hundreds of patients from a suprapubic tube and the periodic torment of urethral dilatation. The Johanson's two-stage technique became so successful that it was used in more and more simple strictures. Nevertheless, the procedure was considered as a complex and difficult operation for a general urologist [15, 20].

The discovery of optical urethrotomy by Hans Sacke from Nurnberg in 1971 became the gold standard of today's endoscopic stricture treatment. During his time at the Department of

Urology at University of Munich, he evaluated internal urethrotomy with the electric knife. He found that the necrosis following the electric incision caused scarring and that this side effect could be avoided for the most part by simple cold-knife incision. In June 1971 he conducted his first operation with the prototype of a cold-knife urethrotomy built by Karl Storz Co., Tuttlingen [21].

The discovery of cold-knife urethrotomy as a minimal invasive procedure decreased the popularity of urethroplasty. The procedure was considered elegant, easy and safe with a reported 23% re-treatment rate. Many urologists began to question the place of urethroplasty in the context of Sachse's optical urethrotomy. The results were that the number of urethroplasties globally fell dramatically [22]. Optical urethrotomy was started for all types and locations of urethral stricture, obliterated and non-obliterated, single or multiple strictures for the next several decades and became the most popular treatment option in the management of urethral strictures.

During the 80s and 90s, many studies showed very interesting rates of success for the endoscopic urethrotomy of urethral stricture management and contributed to the popularity of this method. Some authors even argued the case of "cut to the light" procedure for totally obliterated stricture and intense spongiofibrosis. A review done by Passadoro and Emiliozzi observed a success rate for endoscopic urethrotomy from 56% to 96% in 23 articles. The procedure could be done on an outpatient basis, especially under local or loco-regional anesthesia and this contributed to the popularity of the procedure [23].

Despite the promising results published initially, a contemporary review of the available evidence regarding the success rate for endoscopic urethrotomy was not as favorable, especially in the long-term. Many studies suggest that dilatation and urethrotomy offer equivalent outcomes, but urethrotomies are associated with a high recurrence rate of the stricture requiring repeated procedures over a relatively short period of time. The failure after initial urethrotomy is reported to be 50% and some authors suggest that endoscopic treatment using dilatation or internal urethrotomy exacerbates scar formation and can add

to the length and severity of the stricture. It is also reported that after second internal urethrotomy, the failure rate can be as high as 100% [11, 24, 25]. Santucci R et al. [11] performed a retrospective study of more than 100 patients to evaluate the stricture free rate after a single attempt of internal urethrotomy, and after a second, third, fourth and even after a fifth procedure. He concluded that urethrotomy had poor performance characteristics. The success rates after a first urethrotomy was only 9% after 1–3 years follow up and after multiple urethrotomies it was close to 0%. Additional studies also showed that one dilatation or endoscopic urethrotomy does not complicate stricture characteristic but repeated treatments are associated with increase stricture complexity and are potentially counterproductive [26]. Furthermore, the published data also showed that endoscopic treatment is less effective and cost-effective than urethroplasty [25, 27]. However, many centers of urethral reconstructive urology showed a significant result in terms of stricture free rate for patients treated with urethroplasty. A Cochrane review showed the success rate of urethroplasty to be between 85% and 90% for a simple procedure and about 80% for extreme complex reconstruction. Although no randomized controlled trials were done to compare the effectiveness of internal urethrotomy and urethroplasty, some studies showed that long-term success rates are much higher for urethroplasty (85–90%) than internal urethrotomy (20–30%) [28, 32].

The urological community began to realize that endoscopic urethrotomy is rarely curative and the patient often needs repeated procedures or regular self-dilatation. The scarring in the underlying urethra and adjacent tissue needs to be excised or replaced by healthy epithelium to achieve a cure. Once again, the urological community was questioning the role of endoscopic urethral surgery in the treatment of urethral stricture disease and also questioning the optimal indications for internal urethrotomy or dilatation.

The unsatisfactory result of internal urethrotomy and dilatation led to various attempts being made to modify and increase the durability of this technique. Such approaches included post-

endoscopic urethral catheterization, clean intermittent catheterization (CIC), laser urethrotomy, urethral stenting, antifibroblast and anticollagen injections and steroid injections. None of these modifications could reach as successful rates as open urethral reconstructive management. Following this, urethral stenting was largely abandoned and removed from the market because of limited use and a high rate of complications such as perineal pain, stent migration, stent obstruction, incontinence and infection. Trials are being conducted on the future use of tissue engineering and scar modulation [19, 29–32].

Surgical treatments for urethral stricture disease have been adopted worldwide with significant improvement of successful outcomes and simultaneously a decrease in the complication rate. Urethral surgical technique modification and improvements have been made during the last 30 years to be used in the repair of anterior and posterior urethral stricture/stenosis with the ultimate goal of reducing morbidity and obtaining the best outcome with the least complications. The concept of open urethral reconstructive surgery as a complex and difficult operation is starting to change. Most reconstructive surgeons consider urethroplasty to be the gold standard management for urethral stricture and stenosis. Current data for both EPA and substitution urethroplasty show higher long-term success rates than any other form of management of urethral stricture [32]. From an economic perspective, multiple studies have evaluated the cost-effectiveness of treatment of urethral stricture and found that either immediate urethroplasty or a single attempt of internal urethrotomy, followed by urethroplasty if the procedure failed, was more cost-effective than long-term dilatation or internal urethrotomy with urethroplasty used only for salvage procedures [25, 27].

4.3 Global Standardization of Guidelines for Urethral Stricture Management

Guidelines are evidence-base recommendations that helps health care professionals to promote and protect good health services, improve the

Table 4.2 Strength of the recommendation [36]

Recommendation level	Evidence
Grade A	Well-conducted RCT or exceptionally strong observational study
Grade B	RCT with some weakness of procedure or generalizability strong observational studies
Grade C	Observational studies that are inconsistent, have a small sample sizes, or have other problem that potentially confound interpretation of data
Clinical principle	Statement about a component of clinical care that is widely agreed upon by urologist or other clinicians for which there may or may not be evidence in the medical literature
Expert opinion	Statement, achieved by consensus of panel, based on members clinical training, experience, knowledge

quality of care and prevent complications. A guideline is supported by the strength of the recommendation by using a corresponding grade that indicates the level of evidence provided in the literature (Table 4.2).

There is limited evidence in the literature with regards to urethral stricture disease. Despite this, recommendations were made based on consensus of expert reports, existing evidence from the literature, and the current view of best practice as defined by the experts. At present, there are two guidelines in the urological community for urethral stricture disease. In 2010, the International Consultation on Urological Disease (ICUD) organized an international consensus meeting under the auspices of the Societe International d’Urologie (SIU) and released a guideline on urethral stricture management. It was the first time in the global urological community that terminology was standardized and all aspects of urethral stricture and stenosis were agreed upon with recommendations for clinical practice [18]. Recently, in 2016, the American Urological Association urethral stricture guideline committee also released guidelines for urethral stricture disease with standardized strength of recommendations [17].

4.4 Endoscopic Management

Bayne et al. did a comparative review summarizing the SIU and AUA guidelines with regards to the evaluation, management and follow-up of urethral stricture disease. The results showed relatively the same recommendation of the optimal place for endoscopic management and urethroplasty. One of the major clinical issues to be addressed in these two guidelines is that dilatation and direct vision internal urethrotomy (DVIU) can still be offered in the management of urethral stricture, specifically in short bulbar urethral strictures of 2 cm or less in an untreated stricture. In this clinical situation both procedures mentioned in the guidelines have only a success rate of 50–60% (*SIU; Grade A – AUA; Grade C*). The AUA guideline recommends against repeat DVIU in urethral stricture management (*AUA; Grade A*), but the SIU guidelines (*Grade B recommendation*) showed that repeated DVIU or dilatation is acceptable in solitary strictures, bulbar urethral strictures, stricture length less than 2 cm, and stricture recurrence 3–6 months after

the previous treatment. A third DVIU or dilatation should not be offered, unless the situation is limited by patient comorbidities or resource availability (*SIU; Grade A*). Furthermore, repeat endoscopic treatments carry the risk of exacerbating spongiofibrosis and complicating definitive urethroplasty (*SIU; Grade B*). The AUA guidelines mention that urethroplasty can be used for the initial treatment of bulbar strictures less than 2 cm (*AUA; Grade C*) [17, 18, 36].

In the clinical situation of penile, peno-bulbar, multiple, or longer strictures, urethroplasty should be offered as initial management. The SIU guidelines comment specifically that urethroplasty must be done instead of DVIU or dilatation for obliterative or near obliterative stricture (*Grade A recommendation*). It is also mentioned in the AUA guidelines (*Grade A*) that DVIU or dilatation is not recommended as an initial treatment in pediatric urethral strictures which in this clinical situation has a high stricture recurrence rate (67–78% recurrence over 6 years), and urethroplasty should be offered as the primary intervention [17, 18, 36, 37] (Fig. 4.2).

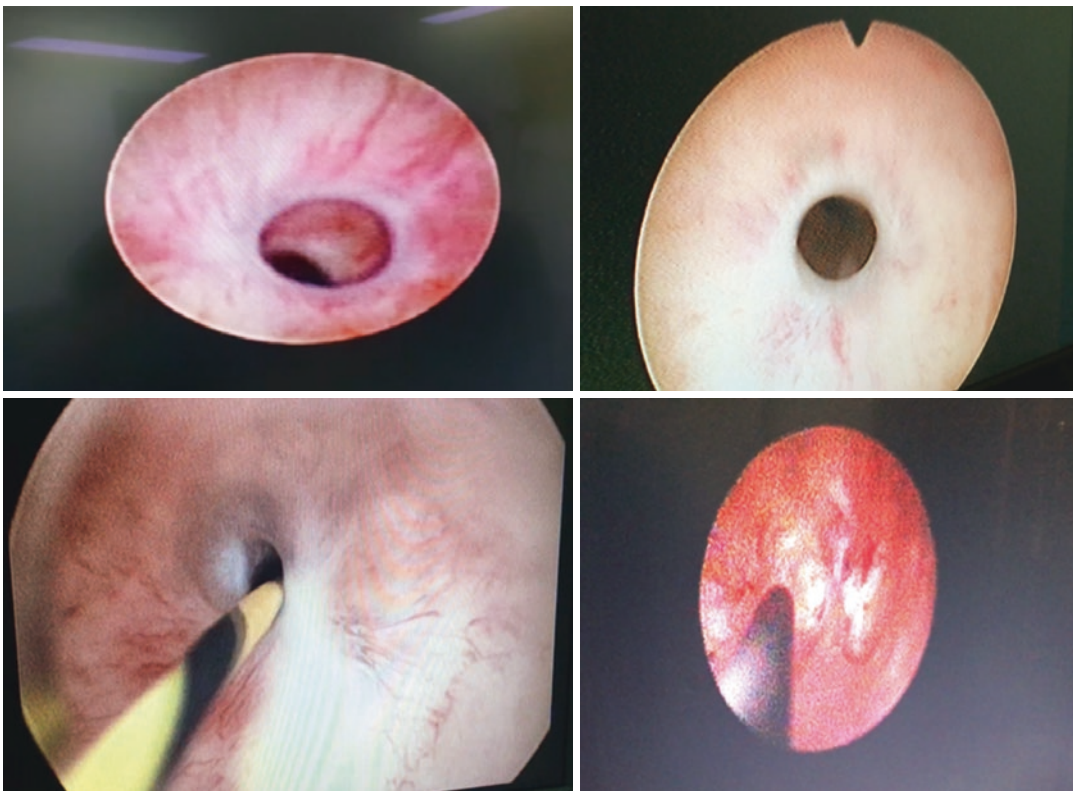


Fig. 4.2 Non obliterative, near-obliterative and obliterative urethral strictures

The application of hot knife urethrotomy with laser urethrotomies are not recommended by SIU guideline with Grade A recommendation due to no evidence of superiority in terms of success rate over cold knife treatment and it is more costly [18, 36] (Fig. 4.3).

Pelvic fracture urethral injuries are completely different from the stricture or stenosis in other parts of the urethra. The dynamics of pelvic-fracture trauma mechanisms result in different injury mechanisms of the urethra. A bulbar crush injury or laceration, membranous avulsion, or membranous disruption and distraction of the urethra could happen. Injuries to the posterior urethra associated with pelvic fracture trauma have been traditionally known as pelvic fracture distraction defects (PFUDD). It was Turner-Warwick who introduced this terminology, however not all patients clinically had distraction

defects. For this reason, the use of PFUDD acronym was discontinued and replaced by PFUI (pelvic fracture urethral injury). Initial management should be the placement of a suprapubic tube less than 16 French in size and positioned in the midline, 2-finger breadth above the pubic symphysis in adult patients. The only place for endoscopic treatment of PFUI is in the acute phase of the trauma. Endoscopic primary realignment can be attempted in stable patients (SIU; Grade B). The purpose of this procedure is to approximate the traumatic ends of the urethra to potentially avoid subsequent stricture formation. Early urethroplasty should be avoided except with concurrent rectal or bladder neck injury (SIU; Grade C). The gold standard of treatment for PFUI is bulbo-prostatic anastomotic urethroplasty with an elaborated perineal approach to achieve a tension-free anastomosis [14] (Fig. 4.4).

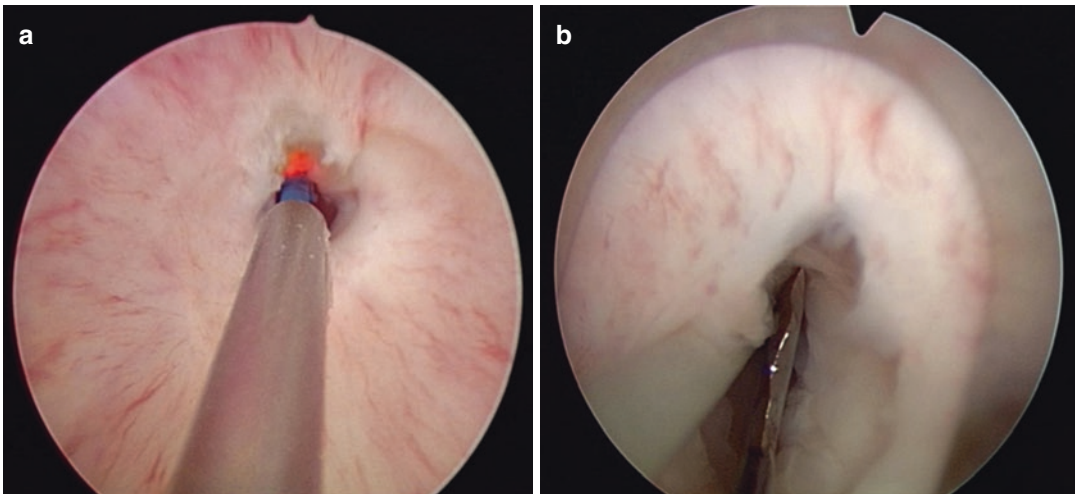


Fig. 4.3 Hot and cold knife urethrotomy. (a) Laser DVIU. (b) Cold-knife DVIU

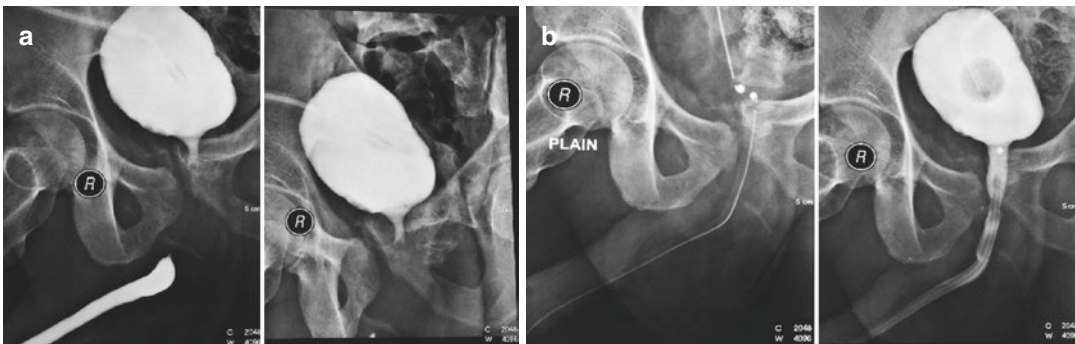


Fig. 4.4 Pelvic fracture urethral injury. (a) Pre-operative VCUG. (b) Post-operative pericatheter urethrogram

Table 4.3 Evolution of urethroplasty for anterior urethral stricture [33, 34]

1953	Stage repair (Johanson)
1992	Oral mucosa graft in Hypospadias (Dessanti)
1993	Oral mucosa graft in urethral surgery-onlay patch (El-Kasaby)
1996	Dorsal onlay (Barbagli)
1996	Ventral onlay (Morey-McAnninch)
1999	Dorsal inlay penile (Hayes-Malone)
2000	Panurethral (Kulkarni)
2001	Dorsal inlay bulbar (Asopa)
2008	Muscle and nerve sparing (Barbagli)
2010	Enterourethroplasty (Mundy)
2015	Non-transecting anastomotic urethroplasty (Mundy)

Table 4.4 Evolution of urethroplasty for posterior urethral stricture/stenosis [35]

1962	Total abdominal pubectomy (Pierce)
1968	Single abdominal incision approach (Paine-Coombes)
1973	Abdominoperineal approach (Waterhouse)
1976	Transpubic approach with omental wrap (turner-Warwick)
1986	Transperineal with pubical wedge excision (Webster-Goldwasser)
1991	Transperineal with elaborated perineal approach (Webster-Ramon)

4.5 Urethroplasty

Urethroplasty is an open surgical technique whereby the narrowed area of the urethra is identified through an appropriate skin incision and the urethra is repaired either by removing the affected area and joining the two healthy ends together (anastomotic urethroplasty) or by opening the narrowed part longitudinally and incorporating graft material or flap tissue materials to keep the lumen open (substitution urethroplasty). It is the definitive procedure for urethral stricture. Urethroplasty has a success rate of up to 95% if done by experienced surgeons [38–40].

Many techniques have been used for urethroplasty, including anastomotic urethroplasty, grafting and the use of flaps with a comparable success rate. Both short-term and long-term success rates are highest for anastomotic urethroplasty, with 15-year recurrence and complication rate of 14% and 7%, respectively [14]. There are many options for reconstructive surgical techniques, and no one technique is appropriate for all stricture diseases [15]. Different techniques of surgical intervention are documented and presented in the literature by various authors from

different countries. The urethral reconstructive urologist needs to be familiar with the use of various techniques to deal with any etiology, location, length and characteristics of the stricture. Proper patient selection and reconstructive techniques will play a role in terms of successful management (Tables 4.3 and 4.4).

4.6 Conclusions

The concept of urethral stricture has been changed from lifetime disease to curable disease with the advancement of urethroplasty technique.

The concept of urethral stricture management started with urethral dilation and internal urethrotomy should be changed to urethroplasty as gold standard management and limit urethrotomy just for certain stricture conditions, considering its high success rate and low recurrence rate of urethroplasty compared to urethrotomy.

There is no single urethroplasty technique that could encompass all stricture conditions. A reconstructive urologist should be familiar with several urethroplasty technique in order to handle the most complicated cases.

Key Summary Points

- Male urethral stricture disease is prevalent worldwide and has a significant impact on quality of life and health-care costs.
- Management of urethral stricture disease has evolved over the last decades but remains complex and largely depends on the characteristics of the stricture and patient-related risk factors as well as surgeon's training and expertise.
- There are various types of urethral strictures, including iatrogenic strictures (as a result of catheterization, instrumentation, and prior hypospadias repair), infectious or inflammatory strictures (caused by gonorrhoea or lichen sclerosus), traumatic strictures (including straddle injuries or pelvic fractures), and congenital or idiopathic strictures. All these stricture types pose different therapeutic challenges.
- The etiology of urethral stricture disease varies geographically. In general, the incidence of infection-related urethral stricture has decreased, especially in the developed world. Nearly a third of urethral stricture cases are idiopathic in origin. The incidence of radiation-induced urethral strictures is on the rise due to widespread use of radiation therapy, either alone or in multimodal treatment protocols for pelvic malignancy. Better understanding and medical treatment of LS would improve control of its subsequent development and recurrence of strictures.
- Workup of US has evolved from simple patient's history of obstructive voiding complaints to a full range of diagnostic tests, including uroflow rate, flexible urethroscopy, retrograde urethrogram and voiding cystourethrogram, urethral ultrasound scan and MRI of the lower urinary tract, depending on the location, complexity and inherent factors of the urethral

stricture. Currently, these tests should enable an optimal operative approach and management strategy.

- There have been considerable advances in urethral surgical technique and optimization of the surgical treatment plan, including emergence of new operative procedures. Both EPA and graft onlay urethroplasty have been used with high long-term success rates, but EPA has a controversial effect on sexual function and this is unacceptable to some reconstructive urologists which has given way to a non-transection modification of bulbar urethroplasty. Augmentation urethroplasty has evolved towards the more extensive use of oral mucosa grafts as compared to penile skin flaps, as both flaps and grafts apparently have similar efficacy and certainly the use of either dorsal or ventral positioning seems to provide comparable results. However, flaps seem to be associated with higher complication rate.
- Generally used in the past, repeated internal urethrotomy and dilatation are not clinically effective or cost-effective. Consequently, urethral stricture management has evolved with results favouring urethroplasty over internal urethrotomy and dilatation. For longer, complex and recurrent strictures, substitution urethroplasty offers excellent outcomes. Intermittent self catheterization appears to offer long term benefit but should be reserved for exceptional patients who are not candidates for open surgery or who refuse it.
- With the variations in strictures, patient characteristics and adverse factors kept in mind and respected, urologists should feel better equipped in counselling patients regarding their treatment options and follow-up.
- It is important that the reconstructive surgeon is well versed in the full range

of available repair techniques, as no single method is suitable for all cases and will enable the management of any unexpected anatomical findings discovered intra-operatively.

- The experimental technologies mentioned above are exciting and ripe with potential. We are cautiously hopeful that these technologies will yield further improvements in the treatment of urethral stricture/stenosis.
- Until then, Urethroplasty should be carried out in specialist centers.

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Clinical Presentation and Diagnostic Evaluation of Male Urethral Stricture

5

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5.1 Introduction

Over the last century, urethral stricture (USx) management has evolved dramatically from the ancient practice of urethral dilation to more complex urethroplasty techniques [1]. While surgical decision making can be complicated the majority of diagnostic tools have remained mostly unchanged for a long period of time [2, 3].

The aim of this chapter is to demonstrate the variation in clinical presentation, diagnostic tests and future possibilities for both preoperative diagnosis and postoperative follow-up of USx.

5.2 Non-invasive Tests: Initial Assessment and Follow-up After Reconstruction

There is a relative lack of evidence regarding the primary presentation of urethral stricture (USx). Structured assessment by means of different Patient-Reported Outcome Measures (PROMs) has predominantly focused on follow-up after urethroplasty, thus, data about primary diagnosis is currently lacking.

5.2.1 Clinical Presentation

In 2012, Rourke et al. [4] described initial complaints and other associated symptoms among 611 patients presenting to a urology clinic with anterior USx. Overall, the most frequent associated symptoms were lower urinary tract symptoms (LUTS), acute urinary retention (AUR), genitourinary pain, and urinary tract infection (UTI), at 92.9%, 29.8%, 22.9% and 20.3%, respectively. The primary presenting complaint were LUTS in 54.3% of the total, followed by AUR and UTI in 23.4% and 6.1%, respectively. Difficult catheterization, gross hematuria, genitourinary pain, urethral abscess/necrotizing fasciitis, renal failure/hydronephrosis, incontinence and sexual dysfunction were present in less than 10% of the cases each. Remarkably, 7.4% of patients had potentially life-threatening complications secondary to anterior stricture.

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Other complications such as urethral discharge, stones, prostatitis, epididymitis, urethral diverticulum, urethrocutaneous fistula, and infected sinuses are not uncommon [5, 6]. It should also be noted that approximately 60% of cases with urethral cancer may present with USx at some point in their disease course [5]. In any patient with an atypical presentation of USx one should consider urethral cancer in the differential diagnosis.

While most strictures are idiopathic, they are also frequently identified in patients presenting with recurrent UTI, ejaculatory dysfunction, lichen sclerosus (LS), hypospadias, or genital trauma, either internally (previous urethral catheterization, TURP, radical prostatectomy) or externally (straddle trauma, pelvic fracture, prior pelvic surgery). When a detailed history is obtained, up to 62.9% of all patients will have an identifiable cause of their stricture [7–9].

5.2.2 Physical Examination

Physical examination is an important aspect of assessment. In patients with a suspected stricture body habitus in general should be noted for any potential difficulties in lithotomy positioning during future procedures. On abdominal examination the bladder may be palpable during abdominal examination, while the presence of a suprapubic catheter (SPC) can facilitate ante-grade assessment of the urethra proximal to the stricture if necessary in the setting of completely obliterated strictures [10]. Examination of the urethral meatus may reveal stenosis or sequelae of hypospadias. A urethrocutaneous fistula may be detected in some instances, particularly in patients who have undergone previous urethral surgery or have longstanding lower urinary tract obstruction. Palpation of the scrotum, perineum and urethra may reveal thickening or induration of the urethra or associated abscess or epididymitis. Urethral induration often indicates severe spongiofibrosis, but if there is an associated mass effect the diagnosis of urethral carcinoma must be considered. Digital rectal examination may help to evaluate prostatic features in both benign

prostatic hyperplasia (BPH) and pelvic fracture urethral injury (PFUI).

Neurological evaluation in the context of a neurogenic bladder or a PFUI is critical because it may affect postoperative care, outcomes such as continence and catheterization, as well as positioning. Severe lower limb spasticity may even contraindicate a urethral reconstruction, favoring upper urinary diversion instead [10].

5.2.3 International Prostate Symptom Score (IPSS) and Other Patient Reported Assessments of Voiding Function

The International Prostate Symptom Score, IPSS (same as AUA-SI, but also including a quality of life domain) is the most widely employed method of patient reported evaluation for bladder outlet obstruction and USx [4, 11]. This questionnaire has been validated in different languages and cultures [12–17]. It was first described for urethroplasty by Morey et al. in 1998 [18] and it is still recommended by the Société Internationale d'Urologie (SIU) and the American Urological Association (AUA) guidelines as part of both preoperative and postoperative evaluation for USx [8, 11].

In the initial assessment of USx, the presence of LUTS, defined as any symptom detected by IPSS, is as high as 92.9% [4]. However, in 2012 Nuss et al. showed that up to 21% of patients presented with symptoms not included on AUA-SI, thus, missing more than one-fifth of the strictures when used alone [11]. Urinary symptoms such as spraying of the urinary stream, post-void dribbling and dysuria are frequently seen in patients with stricture and are not detected by the IPSS. Men with penile USx are more likely to have stream spraying than bulbar strictures were (17% vs. 6%), while LS-associated USx present more frequently with obstructive symptoms (76% vs. 55%) and less frequently with AUR compared with non-LS USx (0% vs. 16%) [11]. Furthermore, bladder stones, prostate and bladder diseases, along with neurourological problems

can also modify IPSS scores, causing a low specificity as a major downside for this test [19–21].

Studies reporting the use of IPSS as patient reported measure after stricture treatment were found in 47% of all published articles between 2000 and 2008 [22]. In this scenario, a dramatic decrease in IPSS (improvement) occurs in patients after urethroplasty except in those with an identified recurrence [18]. Additionally, in 2002 Heyns et al. found that IPSS has an inverse correlation with maximum flow rates ($Q_{\max}$) in patients with USx and thresholds of $Q_{\max} < 15$ ml/sec and IPSS > 10 yielded a sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall accuracy (OA) of 93%, 68%, 78%, 89%, and 82%, respectively, for the diagnosis of USx [23].

However, the lack of symptoms does not necessarily mean unobstructed voiding while an unobstructed voiding does not entail the absence of symptoms [22, 24–26]. A systematic review from 2010 showed that there was no robust evidence supporting the use of IPSS as a condition-specific PROM for urethral reconstruction [27]. Likewise, patient satisfaction does not necessarily agree with physician-defined success [28]. In 2016, Tam et al. published a multi-centered study evaluating 393 men who underwent anterior urethroplasty [25]. Stricture recurrence was defined as the inability to pass a 17F cystoscope. All patients had IPSS decreased postoperatively, regardless of cystoscopic recurrence and the estimated receiver operating characteristic area under curve (ROC AUC) for IPSS was as low as 0.56, indicating a very poor performance when discriminating between those with or without recurrence. Strikingly, if the IPSS cut point of > 10 advocated by Heyns had been used, only 38% of the USx found by cystoscopy as a gold standard (GS) would have been detected [25]. Urethral stricture is clearly more complicated than the simple absence or presence of lower urinary tract symptoms.

On the other hand, sexual dysfunction, chordee, and urethral and bladder pain are significant predictors of dissatisfaction among patients after urethroplasty, emphasizing the need for a comprehensive disease-specific PROM [29, 30].

Currently, there is only one existing PROM for USx assessing LUTS, visual evaluation of the force of the stream, postoperative satisfaction, and quality of life (QoL) along with a visual analogue scale, but unfortunately sexual function is not included in this stricture-specific PROM (USS-PROM) [31–33] (See Appendix 1).

Some of the limitations of the IPSS include poor performance in patients with lower educational level [17, 34, 35]. In order to avoid this concern, a non-validated visual prostate symptom score (VPSS) was developed for assessing LUTS [36]. A study using VPSS was conducted in patients with a previously diagnosed USx found that less educated individuals were more frequently able to respond to the VPSS on their own (68%) than when responding to the IPSS (13%) and VPSS appeared accurate in representing the lower urinary symptoms associated with stricture [37].

More recently, Breyer et al. reported a qualitative study assessing and comparing what patients and urologists considered as their most relevant concerns with regard to USx in the pre- and post-urethroplasty settings. Interestingly, both groups agreed in only 53% of the cases. Patients were mostly worried about “being unable to pee” and having dribbling “in my underwear after peeing”, while physicians considered that straining and weak stream were the most relevant issues [32]. Work is ongoing to further develop a new USS-PROM taking into account more recent findings.

5.2.4 Sexual Function Associated with Urethral Stricture and After Urethroplasty

Coursey et al. were the first to investigate sexual function in men after anterior urethroplasty using a non-validated questionnaire, including circumcised men as a control group. They reported similar incidence of sexual issues after urethroplasty or circumcision [33]. It has been demonstrated that the dorsal nerve of the penis, cavernous nerve, and perineal nerve all interact in providing sensation, motor, and autonomic innervation to the penis and control sexual func-

tion and thusly are relevant anatomical landmarks to be considered when performing urethroplasty [38–40]. The impact of USx on sexual health can be divided into three main domains, erectile dysfunction (ED), ejaculatory dysfunction (EjD), and chordee/penile shortening. Probably due to the aforementioned anatomical characteristics, sexual dysfunction (SD) is more commonly present in the context of a pelvic fracture urethral injury (PFUI) than it is with anterior USx [41].

5.2.4.1 Erectile Dysfunction

Preoperative ED, spontaneously reported by patients having anterior USx, without using any questionnaire, has been found in 11–12% as part of their presenting complaint, while prospective studies using the International Index of Erectile Function (IIEF) have found ED in as many as 44% of cases, preoperatively [4, 11, 42].

The IIEF was first used by Anger et al. to prospectively compare the frequency of ED between pre and postoperative setting among 25 subjects undergoing anterior urethral reconstruction [43]. They did not find any significant difference in ED after surgery, however, the incidence of new onset erectile dysfunction was not assessed. Subsequently, ED has been reported in 25–38% at 4 and 2 months after urethroplasty, using the Brief Male Sexual Function Inventory (BMSFI) and IIEF, respectively [44, 45]. Sixty-six percent of individuals had an early postoperative ED, but fortunately, 90% of patients fully recovered at a mean of 190 days postoperatively, which is consistent among studies [42, 46–50].

A meta-analysis from 1997 to 2012 reported *de novo* ED after anterior urethral reconstruction, with an overall rate of 1% that ranged from 0% to 38% (CI 1–3%) [45]. Only 5 out of 21 studies found a rate $\geq 20\%$, while, interestingly, all of these studies used validated questionnaires and were conducted after 2001. Postoperative ED seems to be higher for bulbar (76%) compared with penile strictures (38%) [42]. The authors stated that older studies could have underrated *de novo* ED, based on the high heterogeneity among studies. They also hypothesized that transient early ED may be attributable to either temporary

psychological impact or quickly resolving vascular injuries.

In the setting of PFUI, “*it is difficult to differentiate between ED due to PFUI and de novo ED due to urethral realignment or delayed urethroplasty...*” [51]. Vascular and neurological damage along with tunica albuginea injury may lead to venous leakage or intracavernosal fibrosis [47]. There is a reported ED rate of 20% in patients after pelvic fracture alone, regardless of the presence of PFUI [52]. Age, severity, type of pelvic trauma, and urethral involvement are associated with a higher risk of ED [48, 49]. A systematic review and meta-analysis of 24 studies, revealed that 34% of patients with PFUI reported ED before undergoing delayed urethroplasty [51]. However, formal urethroplasty resulted in an additional 3% rate of *de novo* ED [50, 53, 54]. It has even been argued that posterior urethroplasty may improve the erectile function in up to 16–66% of individuals having ED after PFUI [55, 56]. On balance, ED in the setting of PFUI is mainly related to the primary trauma rather than to the reconstruction itself.

5.2.4.2 Ejaculatory Dysfunction

Normal ejaculation depends on several anatomic structures and is under the efferent control of the inferior hypogastric plexus and pudendal nerve rami [38, 57]. Ejaculatory dysfunction may be caused primarily by USx and can potentially occur after urethroplasty. Injury to the bulbospongiosus muscle (BS) may also lead to an impaired ejaculation [58]. In 2012, Rourke et al. found that sexual dysfunction was present in 12.1% of subjects with USx, almost exclusively owing to EjD [4]. More recently, a systematic review showed that validated questionnaires for EjD were utilized infrequently. However, preoperative EjD was present in up to 85% of patients with USx and more frequently in older subjects and patients with bulbar strictures. After anterior urethroplasty, ejaculatory function improves in 12–65%, remains unchanged in 0–23%, and worsens in 0–19% of patients [59, 60]. No significant association was found between stricture length, stricture location or muscle transection and postoperative EjD. However, a higher risk of

EjD was associated with advancing age and ventral onlay grafting, possibly related to semen pooling in a urethral pseudodiverticulum [59].

Ejaculatory function data in the setting of posterior urethral stenosis is lacking, predominantly retrospective and exclusively related to PFUI [61, 62]. Preoperatively patients commonly have EjD related to complete urethral obstruction. After reconstruction, 98.3–100% recovered antegrade ejaculation, but 1.7–39.6% had some degree of EjD, which is likely caused by the PFUI rather than the repair itself [61, 62]. Overall, improvements after either anterior or posterior urethroplasty are presumably due to a lower resistance along the urethra after repair.

5.2.4.3 Chordee and Penile Shortening

In 2016, Bertrand et al. prospectively evaluated risk factors for postoperative dissatisfaction after anterior urethroplasty, and found a higher rate of penile curvature (35% vs. 17%) and penile shortening (48% vs. 32%) among dissatisfied individuals [29]. This is consistent with a later prospective study by Maciejewski et al. who found both shortening (OR 2.26, 95% CI 1.38–3.69, $p = 0.001$) and chordee (OR 2.46, 95% CI 1.44–4.19, $p = 0.001$) to be independent strong predictors of dissatisfaction after urethroplasty [30]. While chordee and penile shortening are not common after USx treatment their occurrence greatly impacts patient satisfaction and should be captured in clinical assessments.

5.2.5 Uroflowmetry and Post-void Residual Urine Measurement

Uroflowmetry (UFM) is a simple functional non-invasive test which essentially measures the urinary output flow (volume/time) and its characteristics, such as peak and average flow rates ($Q_{\max}$ and Q_{avg} , respectively), voiding volume (VV), time, and pattern [63].

The so-called “classic” pattern of USx is a decreased $Q_{\max}$, flat-shaped curve, and increased voiding time. In spite of this, it has been evidenced that no UFM characteristics can objectively and reliably distinguish between bladder

outlet obstruction (BOO) and detrusor impaired contractility [64]. Conditions that may affect UFM, other than USx, are impaired detrusor contractility, BPH, detrusor sphincter dyssynergia, and pelvic floor dysfunction. The simultaneous measurement of both UFM and detrusor pressure (P_{det}), namely, the pressure-flow study, is the only way to reliably confirm obstruction [64–66]. Despite these limitations UFM is commonly used to evaluate USx.

With respect to the initial diagnosis of USx, Heyns et al. demonstrated that $Q_{\max}$ had a significant association with both IPSS (negatively) and urethral caliber (positively) among patients presenting to a urology clinic with USx [23]. When combining the cutoff values of $Q_{\max} < 15$ ml/sec and IPSS > 10 , they obtained a 93% sensitivity, 68% specificity, and 82% OA, while only 4.3% of USx would have been missed. On the other hand, different studies reported preoperative mean $Q_{\max}$ ranging from 9.4–11.8 ml/sec [24, 60]. More recently, Lambert et al. designed a mathematical model to discriminate between USx and BPH based in UFM parameters only. The model achieved a sensitivity of 80%, specificity of 78%, PPV of 76.9%, NPV of 79.2%, and a ROC AUC of 0.84 when discriminating between BOO secondary to BPH vs. USx [67]. However, the model could not distinguish decreased flow due to BOO from impaired detrusor function and the authors advise against its use in diabetics or subjects with possible neurological conditions. At any rate, both AUA and SIU guidelines on USx recommend the use of UFM in the preoperative evaluation of USx [8, 9, 68].

In the post-urethroplasty context, UFM has been used in 56% of published papers [22]. In these circumstances, the main question is whether UFM can replace invasive testing when detecting stricture recurrence after urethroplasty or not. Uroflowmetry diagnostic performance typically depends on what test is being used as a GS and on stricture prevalence in the reference population. Because of these factors there has been generally inconsistent results. When a $Q_{\max}$ cutoff < 10 ml/sec is used alone, Erickson et al. reported a 54% sensitivity, 93% specificity, 73% PPV, and 86% NPV in detecting failures after repair, when

retrograde/voiding urethrogram (RUG/VCUG) were utilized as a GS. Interestingly, they showed that 30% of recurrences had a $Q_{\max} > 15$ ml/sec inferring that 30% of recurrences would be missed with the use of UFM alone. Conversely, by means of a subjective interpretation of UFM curve, they found 93% sensitivity and 84% specificity [69]. Later, it was demonstrated that $\Delta Q_{\max}$ (postoperative $Q_{\max}$ – preoperative $Q_{\max}$) was a much better predictor of failure than $Q_{\max}$ alone [60].

In 2016, Tam et al. published a prospective multi-institutional study including 323 subjects who were followed-up over a mean of 12.8 months after anterior urethroplasty [24]. Unlike the previous studies, they used cystoscopy as a GS. There was no difference when comparing either postoperative $Q_{\max}$ or a novel $Q_{\max}$ - Q_a value. For a $Q_{\max}$ cutpoint of <10 ml/sec, they found a sensitivity as low as 21%, while for a $Q_{\max}$ - Q_a of ≤ 10 ml/sec sensitivity was 83% and specificity only 58%. Both $Q_{\max}$ and $Q_{\max}$ - Q_a had a significantly better performance for patients ≤ 40 years, likely due to a higher prevalence of BPH and weak detrusor among the elderly [24]. Therefore, the use of UFM alone as a screening for USx recurrence seems to have an unacceptably poor performance. Despite the above, using preoperative UFM along with patient reported measures is consistently recommended as a baseline to compare future outcomes, incorporating patient's perspective [8, 68]. Likewise, several UFM calculated values along with PROMs may give an acceptable screening yield for recurrences, but only if cystoscopy is performed at some point of the follow-up [18, 23, 25, 37, 70]. On balance, uroflowmetry may be a useful "screening" tool to diagnose USx but confirmation of a USx requires either cystoscopy or urethrography.

Post-void residual (PVR) urine, measured by either in-and-out catheterization or ultrasound, is considered part of the objective assessment of the voiding function alongside UFM, and has been reported as a screening test in 8% of studies [22]. However, many factors can alter PVR urine findings and an elevated PVR urine likely only occurs in the setting of detrusor decompensation, so it

should likely never be used alone for primary diagnosis of USx or for follow-up after stricture surgery [70]. In any case, PVR may be valuable as an adjunctive test in determining the risk of bladder failure or impending upper tract dysfunction secondary to chronic urinary retention due to USx [70].

5.3 Invasive Tests: Definite Diagnosis and Staging

5.3.1 Cystourethroscopy

Direct visualization of the urethra and the bladder has been present in urological practice as a diagnostic tool for a very long time [3]. Either rigid or flexible cystoscopes can be found in almost every urology service and almost every urologist at every level of training is able to use them properly. Cystourethroscopy (CU) has a critical importance for the reconstructive urologist because "*as a diagnostic modality, cystoscopy has been considered the gold standard for determining the presence or absence of a urethral stricture*" [68].

It has been claimed that RUG/VCUG alone may be sufficient to definitively diagnose and stage a USx. Nonetheless, not to perform CU may lead to missed valuable information, such as the presence of concurrent lower urinary tract pathology such as tumor, urinary calculi, hair-bearing tissues (after prior urethroplasty), bladder neck status, BPH or simply unhealthy urothelium.

While the AUA guidelines declare that either RUG/VCUG or CU are necessary to establish a USx diagnosis, the SIU guidelines state that CU and RUG are recommended as Grade A investigations, VCUG at Grade B, and urethral ultrasound at Grade C. On one hand, RUG/VCUG are able to accurately estimate the length and location of the stricture, while on the other hand as a binary measure, CU is the most specific test for diagnosing USx but is not able to accurately determine stricture length [8, 9, 68, 71, 72].

In 1968, Smith demonstrated that the urinary flow decreases and symptoms occur once the

urethral caliber is <11F. Before that, the bladder can maintain a normal urinary flow at the expense of abnormally high voiding pressures, therefore, symptoms which make the patient seek medical care may become evident long after urinary pressures have been present for a long period of time [73]. Thus, complications may arise from undiagnosed USx or urethroplasty failures in the absence of decreased flow or urinary symptoms [4, 6]. In this respect, several prospective studies have consistently concluded that the best way to define anatomical success and to compare outcomes between institutions after urethral repairs is *“the ability to pass a 16F-17F cystoscope beyond the area of reconstruction with ease”*, overcoming the performance of UFM, PROMs, and even that of RUG/VCUG [26, 74, 75]. But this may be far from real practice, in 2013, Yeung et al. published a survey of members of the Society of Genitourinary Reconstructive Surgeons in which 60% of respondents defined surgical failure as the need for a secondary procedure, 14.4% did so based on RUG/VCUG findings, and only 12.2% used CU [76].

Our recommendation is that once BOO is suspected, a physical examination alongside with non-invasive tests, such as questionnaires and UFM and PVR urine measurement, may be utilized as a screening assessment. However, if USx is a likely diagnosis, a CU should be booked before or simultaneously with a RUG/VCUG. Preferably, CU is performed under local anesthetic using a 16F-17F flexible instrument. In certain cases, such as meatal/fossa navicularis strictures, we have found that a semi-rigid pediatric cystoscope (6F-8F) can be of great help and provide valuable information about stricture length, urethral caliber, presence of LS, and severity of spongiofibrosis with minimal urethral trauma [75]. Ideally, CU should be performed with the patient lying on a radiolucent table, so that, a RUG/VCUG can be done simultaneously.

Cystourethroscopy does have some potential disadvantages. First of all, it is an invasive test, thus, individuals may complain of postprocedural hematuria, bladder/urethral pain, and rarely urinary tract infections. Secondly, it can be costly in certain environments [77]. Thirdly,

after urethroplasty up to 35% of subjects with a cystoscopic recurrence were asymptomatic. Thus, it is unclear if cystoscopy is an overly sensitive means of detecting USx. These factors may limit the use of CU during follow-up, especially when patients have minimal symptoms (normal flow, no LUTS, normal EjF, etc.) and it has been reported that only 54.4% of patients are compliant with a 1-year cystoscopic follow-up after urethroplasty [26]. One final important consideration is that the vast majority stricture recurrences can be diagnosed within the first year with cystoscopic assessment and cystoscopy is likely not required long-term after intervention [78]. If cystoscopy was used indefinitely to detect long-term stricture recurrence after urethroplasty, approximately 110–162 normal CU would be required to detect 1 recurrence on a yearly basis [79, 80]. It seems clear that cystoscopy is not required long-term but is likely required at least once after urethroplasty as a means stratify the risk of recurrence. At risk individuals can then be followed more closely in order to adapt to different clinical scenarios and care models.

5.3.2 Retrograde Urethrogram and Voiding Cystourethrogram

Given that RUG/VCUG have been consistently used for over a 100 years, reconstructive urologists are familiar with these techniques, whereas general urologists may be not. As mentioned above, for many, RUG/VCUG is considered the GS for USx staging, while CU remains the study of choice for determining whether a USx is present or not [8, 68]. Sensitivity, specificity, PPV, and NPV for RUG/VCUG for the diagnosis of USx has been found to be 75–100%, 72–97%, 50–93%, and 76–100%, respectively, when CU or intraoperative findings were used as a GS [72, 81]. (Fig. 5.2). A well-performed RUG/VCUG (Figs. 5.1, 5.2, and 5.3) should identify several key stricture characteristics including length, location, and number, along with information



Fig. 5.1 Proper positioning for retrograde urethrogram. In particular, note the occlusion of the downward left obturator fossa. Also, an incidental urethral stone is also evident



Fig. 5.2 A properly performed and normal retrograde urethrogram. The four distinct parts and bladder are labelled accordingly: p = penile urethra, b = bulbar urethra, m = membranous urethra, pr = prostatic urethra, b = bladder

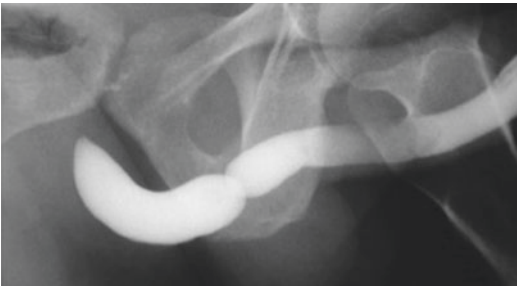


Fig. 5.3 These two urethrograms on the same patient without and with proper oblique positioning demonstrate the importance of proper positioning during urethrogram.



Without a sufficient oblique positioning the presence and length of stricture can be underestimated

regarding associated pathology (Figs. 5.4, 5.5, 5.6, and 5.7) [10, 82]. Data that is critical for surgical decision making.

Retrograde urethrogram is strongly recommended to explore the anterior urethra, but either under or overestimation of USx length and/or location might occur when assessing membranous-prostatic urethra or bladder neck, as they normally remain closed during bladder filling phase. VCUG combined with RUG is helpful in additionally assessing the posterior urethra, as long as reliable micturition can be achieved (Fig. 5.8) [10]. Voiding imaging can fail to delineate posterior stenosis or PFUI when the patient is not able to void, due to bladder neck contracture, urethral distraction, detrusor-sphincter dyssynergia, prostatic fibrosis/necrosis, underactive detrusor, or simple psychological inhibition to void [10]. If reliable micturition cannot be achieved combined assessment with cystoscopy is frequently helpful particularly in the case of obliterated posterior urethral stenoses from either pelvic fracture (Figs. 5.9 and 5.10) or radical prostatectomy (Fig. 5.11). Besides evaluating for posterior stenoses, VCUG may also provide important information about functional status, such as vesicoureteral reflux, risk of incontinence after urethral repair in the context of an open bladder neck at rest, and a non-relaxing bladder neck or external sphincter [83]. For the above, it is recommended to perform RUG in conjunction with VCUG, whenever possible [10].



Fig. 5.4 A short segment bulbar urethral stricture identified on retrograde urethrogram

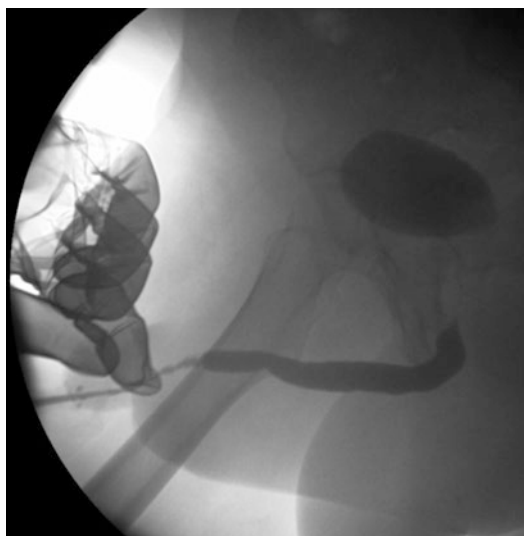


Fig. 5.6 A retrograde urethrogram demonstrating a penile urethral stricture related to prior hypospadias surgery



Fig. 5.5 A longer and more complex bulbar urethral stricture with false passages. Note the concurrent filling of Cowper's gland



Fig. 5.7 A retrograde urethrogram demonstrating a non-obiterated urethral stenosis associated with a pelvic fracture injury

Limitations of RUG mainly occur when strictures are at either the proximal or distal (fossa navicularis) ends of the anterior urethra. In the case of meatal/fossa strictures, it may be difficult to secure a device to inject contrast into the meatus and in doing so meatal strictures may be obscured. Hypospadias, a redundant foreskin, and buried penis all make RUG more difficult. In this case the use of a pediatric cystoscope (Fig. 5.12) or semi-rigid ureteroscope can help more accurately stage and evaluate distal penile urethral stricture. Additionally, it is not possible to accurately assess spongiofibrosis using RUG alone, however, experienced urologists may be

able to infer this. When evaluating proximal bulbar-membranous strictures the normal sphincter narrowing may be mistaken as a USx [10]. RUG/VCUG also require significant radiation exposure. Normally, RUG exposes the subject to 1–2 mSv, similar to radiation received during 20 chest radiographs [78].

Finally, it is strongly recommended that RUG/VCUG should be performed and interpreted by

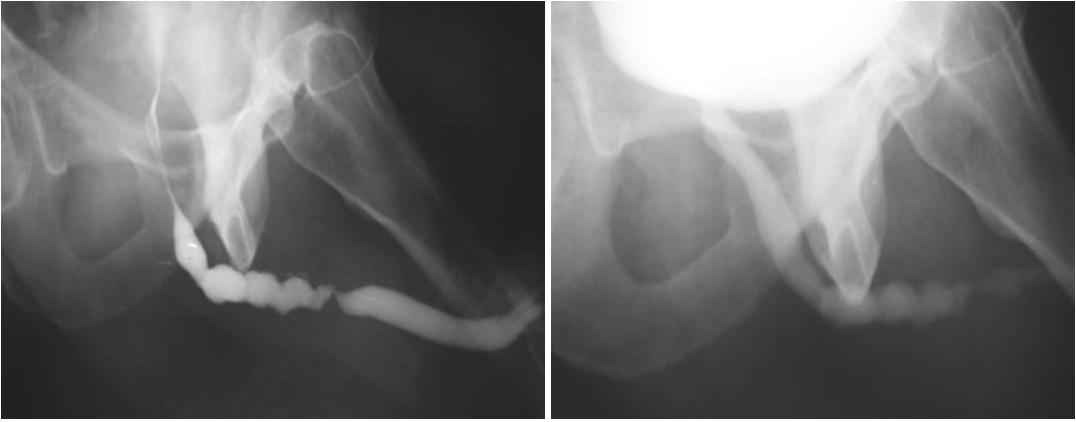


Fig. 5.8 Retrograde urethrogram (left) and voiding cystourethrogram (right) used to delineate a long segment bulbar urethral stricture



Fig. 5.9 Combined retrograde urethrogram and voiding cystourethrogram to evaluate a urethral defect in the setting of a pelvic fracture urethral injury. In this case there is an overestimation of urethral defect length due to lack of spontaneous voiding, failure to relax the bladder neck and associated complete urethral obliteration

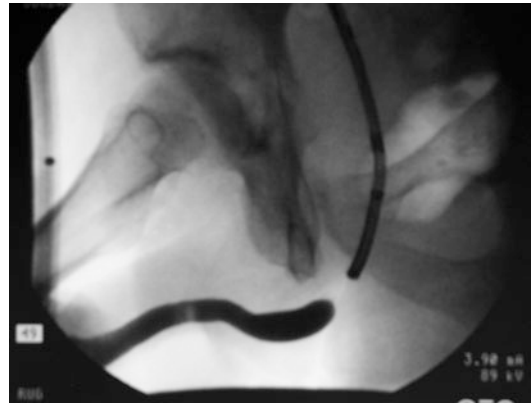


Fig. 5.10 Combined antegrade flexible cystoscopy and retrograde urethrogram to more accurately assess urethral defect length in the setting of a pelvic fracture urethral injury

the urologist under dynamic fluoroscopy rather than static images [84, 85]. Details about procedure performance are found in the [Appendix 2](#) [10, 85, 86].

5.3.3 Urethral Ultrasound and Sonourethrography

This test was consecutively described by McAninch and Merkle in 1988, [87, 88] reporting good diagnostic performance. Choudhary et al. subsequently prospectively analyzed 70 men with



Fig. 5.11 Cystogram combined with antegrade cystoscopy and retrograde urethrogram to demonstrate a complex obliterated vesicourethral anastomotic distraction after radical prostatectomy

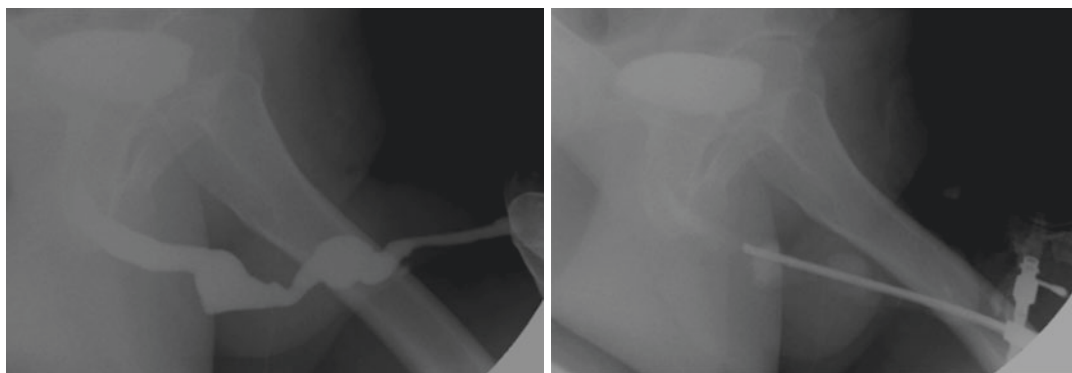


Fig. 5.12 A pediatric cystoscope using in conjunction with retrograde urethrogram to better delineate a distal penile urethral stricture with meatal involvement

LUTS and anterior stricture comparing both RUG and high resolution sonourethrography (SUG) with intraoperative findings as a GS. Depending on the stricture length, they reported a sensitivity, specificity, PPV, NPV, and OA of 67–100%, 95–98%, 50–97%, 93–100%, and 90–97%, respectively, with SUG, showing a better performance than RUG did [72]. Nevertheless, in this study RUG interpretation was done by radiologist, which has a lower diagnostic yield than those done by urologists [84]. As expected, SUG is not helpful for posterior stenosis and should be discouraged for this purpose [89–92].

Several other studies have also shown excellent performance of SUG with sensitivity up to 98% and a specificity up to 96% [93]. Typically, USx length is consistently underestimated by RUG and better depicted by SUG [94–97]. In particular, underestimation of bulbar strictures length on RUG is greater because of the oblique position used for this procedure.

Other advantages of SUG compared with RUG include no risk of contrast-induced reaction, no exposure to ionizing radiation, information about periurethral tissue and potential cost-effectiveness [72, 89, 98, 99, 100]. In 2016, Bryk et al., demonstrated for the first time that, alongside cystoscopy, SUG may be feasible as the only form of imaging without the need for RUG [95].

Conversely others believe and have demonstrated that a properly performed and interpreted RUG remains the most accurate investigation for stricture staging with no difference between SUG and RUG regarding length, diameter or severity of USx [82]. Poorly performed RUGs may be the main reason for previously detected differences [82]. Despite its good performance for anterior strictures, very few studies and urologists utilize SUG as their main investigation and even fewer (8%) use it for follow-up [22]. The downside of SUG is that it is highly operator dependent, invasive, labour intensive, and requires local or general anesthesia for full urethral distension to maximize visualization [86, 90]. The fact that most urologists are not familiar with the SUG technique, its relative complexity, and its inability to adequately evaluate posterior urethra are the main reasons its use is limited. (See [Appendix 3](#)).

In 2018, Chen et al., proposed the three-dimensional (3D) SUG as a better way to evaluate anterior urethra, giving an easily interpretable display for the urologist to make future surgical decisions, especially improving fossa navicularis assessment [101]. However, USx longer than 4 cm are not able to be 3D-reconstructed and images take up to 1 day to be completed [102, 103].

5.4 Cross Sectional Imaging

Posterior stenosis, PFUI, complete urethral obliteration, fistulae, false passages, concurrent tumor and urethral diverticula are complex stricture scenarios that can complicate accurate stricture diagnosis and staging with traditional modalities. Magnetic resonance urethrography (MRU) and spiral CT cystourethrography (CTCUG) might be used as an adjunct to CU and RUG/VCUG to obtain valuable complementary information in these cases [68]. Both MRU and CTCUG are performed with the concurrent injection of sterile jelly/saline or contrast for the retrograde phase, respectively. Voiding is also attempted to get a better observation of the posterior urethra.

5.4.1 Magnetic Resonance Urethrography (MRU)

In 1992, the first MRU series was published, demonstrating a more accurate preoperative assessment in PFUI compared with RUG/VCUG [104]. Since then, most of the studies have consistently reported better performance of MRU in providing supplementary data (in up to 35% of the cases), such as the degree of spongiositis, fistulae, and urothelial tumors, along with a higher correlation of surgical urethral defect length ($r^2 = 0.62$ vs. $r^2 = 0.001$) [96, 97, 102]. Furthermore, a proper delineation of defect length can be done by MRU in 86% of individuals with PFUI, whereas RUG/VCUG fails in doing so in up to 29% of cases, mainly because they are unable to open the bladder neck during voiding studies [105]. Prostatic displacement secondary to PFUI, either superiorly or laterally, can be easily depicted by MRU and, when present, it might predict a tedious dissection or even the need of an abdominoperineal approach. Lateral displacement of the prostate and avulsion of the corpora cavernosa have been frequently seen in patients with ED after PFUI. It has been advocated that MRU may have a critical impact on surgical decision-making in PFUI [105, 106].

Main drawbacks of MRU are its difficult performance and interpretation, the invasiveness

(sterile lubricating jelly or saline is injected into the urethra), it is time-consuming, its limited availability, metal contraindicates its use (which is often present after pelvic fracture repairs), and is approximately three times more expensive than RUG/VCUG or SUG are [100]. To our knowledge MRU has not been described for follow-up after urethroplasty.

5.4.2 Computed Tomography Cystourethrography (CTCUG)

In 2003, 3D-CTCUG was first described by El-Kassaby et al., in 21 PFUI individuals, who simultaneously underwent RUG/VCUG. They concluded that 3D-CTCUG could better determine location and length of the defects, urethral alignment, bony sequelae of the fracture, fistulas, diverticula, and false passages. However, no statistics were used to support this conclusion [107]. Later, Zhang et al., reported findings in 21 patients with posterior stenosis, comparing 64-row multi-detector CTCUG with RUG/VCUG. Both modalities did not have significant differences when compared with intraoperative findings regarding defect length and OA, whereas additional data was provided by CTCUG in 48% of cases, impacting surgical planning (recto-urethral fistula and proximal urethral delineation) [108]. Moreover, Sa et al., described CTCUG to overcome RUG/VCUG in its accuracy to determine the location of the stricture (93% vs. 71%) and the presence of fistulas (100% vs. 71%) [103]. Further advantages such as avoiding physicians' radiation exposure, single positioning (supine), shorter procedure time, and easier interpretation, have been also found [108]. Images can be captured either during retrograde contrast injection and/or while voiding [100]. Recently, CT Virtual Endoscopy (CTVE) has been developed [109–111]. Feng et al., showed a shorter procedure time for CTVE compared with conventional CU, but it was not significantly better in detecting fistulae and false passages [110]. Some of the downsides of CTCUG are a lack of evidence concerning its use for anterior USx, radiation dose is three to six times higher than that delivered during standard

RUG/VCUG, a risk of contrast allergy reaction, difficult performance, its invasiveness, increased cost, and inability to delineate spongiositis [100, 108, 112].

Based on the current evidence, both MRU and CTCUG may be helpful for traumatic USx, posterior stenosis (especially PFUI), and for cases in which coexistent pathology is suspected [68].

5.5 Conclusion

In summary, as an initial diagnostic tool, patient reported assessments are helpful when screening patients for stricture and obtaining a picture of the symptoms most affecting these patients. In the preoperative setting IPSS is the most commonly utilized patient reported measure, but does not assess QoL or sexual function. When patient reported outcome measures are used in combination with the information obtained from UFM, they raise a strong suspicion of USx. In spite of this, they can only be used as adjuncts to cystoscopy and/or RUG/VCUG, which are ultimately required to confirm the diagnosis of USx. Retrograde urethrogram remains the GS for staging USx with regard to length and location with an emerging role for CT and MRI in assessing posterior stenoses or complex strictures.

In the postoperative setting, it has been widely agreed that PROMs including urinary symptoms, quality of life, and sexual function should be periodically used in addition to UFM for follow-up, since they are critical when considering the patients' perspective and serve as a baseline evaluation. However, PROMs and UFM may miss significant failures and place patients at risk for stricture-related complications. Our recommendation is to perform CU at least once within the first year after intervention as a means to screen for and predict the risk of stricture recurrence. If CU is normal, further follow-up may be performed based on PROMs, UFM, and pre-operative stricture characteristics. When a failure is detected, RUG/VCUG should be performed for further staging and decision-making. This is consistent with both the SIU-ICUD and the AUA Guidelines on Male Urethral Strictures [8–10, 68].

A comprehensive definition of success after treatment is still to be determined, however, it should incorporate all anatomic urethral success, objective functional success, subjective voiding and subjective non-voiding patient satisfaction.

Key Summary Points

- As an initial diagnostic tool, patient reported assessments are helpful when screening patients for stricture and obtaining a picture of the symptoms most affecting these patients.
- While patient reported outcome measures are important, cystoscopy or urethrogram are ultimately required to confirm the diagnosis of urethral stricture.
- Retrograde urethrogram remains the gold standard for staging urethral stricture with regard to length and location with an emerging role for CT and MRI in assessing posterior stenoses or complex strictures.
- In the postoperative setting, it has been widely agreed that patient reported outcome measures (PROMs) including urinary symptoms, quality of life, and sexual function should be periodically used for follow-up, since they are critical when considering the patients' perspective and serve as a baseline evaluation. However, PROMs and uroflowmetry may miss significant failures and place patients at risk for stricture-related complications. Our recommendation is to perform cystourethroscopy at least once within the first year after intervention as a means to screen for and predict the risk of stricture recurrence.
- A comprehensive definition of success after treatment is still to be determined, however, it should incorporate all anatomic urethral success, objective functional success, subjective voiding and subjective non-voiding patient satisfaction.

Appendices: Clinical Presentation and Diagnostic Evaluation of Urethral Stricture

Appendix 1

Thank you for completing this questionnaire. The following questions are designed to measure the effect that urethral strictures have on patients' lives.

Some questions may look the same but each one is different. Please take time to read and answer each question carefully, and tick the box that best describes your symptoms over the past 4 weeks.

If you currently have a urethral or suprapubic catheter (a catheter through the lower abdomen) please start at page 4.

1 Is there a delay before you start to urinate?

- | | |
|------------------|--------------------------|
| Never | ☐ |
| Occasionally | ☐ |
| Sometimes | ☐ |
| Most of the time | ☐ |
| All of the time | ☐ |

2 Would you say that the strength of your urinary stream is...

- | | |
|--------------------------|--------------------------|
| Normal | ☐ |
| Occasionally reduced | ☐ |
| Sometimes reduced | ☐ |
| Reduced most of the time | ☐ |
| Reduced all of the time | ☐ |

3 Do you have to strain to continue urinating?

- | | |
|------------------|--------------------------|
| Never | ☐ |
| Occasionally | ☐ |
| Sometimes | ☐ |
| Most of the time | ☐ |
| All of the time | ☐ |

4 Do you stop and start more than once while you urinate?

- | | |
|------------------|--------------------------|
| Never | ☐ |
| Occasionally | ☐ |
| Sometimes | ☐ |
| Most of the time | ☐ |
| All of the time | ☐ |

5 How often do you feel your bladder has not emptied properly after you have urinated?

- | | |
|------------------|--------------------------|
| Never | ☐ |
| Occasionally | ☐ |
| Sometimes | ☐ |
| Most of the time | ☐ |
| All of the time | ☐ |

6 How often have you had a slight wetting of your pants a few minutes after you had finished urinating and had dressed yourself?

- | | |
|------------------|--------------------------|
| Never | ☐ |
| Occasionally | ☐ |
| Sometimes | ☐ |
| Most of the time | ☐ |
| All of the time | ☐ |

Appendix 2

Procedure Description for RUG/VCUG

Materials. Antiseptic solution to prep and sterile field should be available for draping. Our recommendation is to use a 60 ml syringe with a catheter tip adaptor and a long gauze to wrap and hold the penis. Alternatives are to utilize a 6-12F Foley's catheter or a Brodny's clamp. Inner sheath of intravenous catheter may be useful for meatal strictures. Intraurethral anesthetic lubrication is not recommended. Approximately 30–60 ml of water-soluble contrast (e.g., diatrizoate meglumine or iohexol). A tray should be available if VCUG is planned. Lead gloves and apron for the staff are required.

Positioning. Subjects (specially their pelvis) should be placed obliquely at 20°–45° on a radiolucent stretcher, with the bottom hip flexed at 45°–90° and the top leg stretched down. Whether to use a right- or left-oblique positioning, is totally upon surgeon's preference, as long as he/she stands on the opposite side of the screening arm. When positioning is correct, a scout film should show the lower obturator fossa completely closed, this prevents a potential underestimation of bulbar strictures length.

Fluoroscopy and Normal Findings. Scout film can detect stones, urethral or ureteral stents, staples or brachytherapy seeds. The long gauze is placed gently wrapping the penis, just below the corona, stretching it to get an optimal estimation of the urethral length. Contrast is then slowly injected under continuous fluoroscopy, demonstrating urethral distensibility, while saving sequential pictures. The goal is to see contrast passing through both the stricture and the membranous urethra, at least. Bladder filling for VCUG can be achieved by either RUG instillation or through a SPC (when placed beforehand).

Normal findings on RUG are: a uniform and smooth but narrower penile urethra transitioning to a wider bulbar urethra in an

S-shaped fashion at the penoscrotal (penobulbar) junction; a bulbar tapering into membranous urethra forming a symmetrical cone which continues as a 1–2 cm long faint strand, representing the membranous urethra; then, an oval filling defect corresponding to the verumontanum is seen, along with a slight widening at the prostatic urethra; finally, the most proximal narrow segment before the bladder is the bladder neck. Under normal conditions, the posterior urethra will not be distended by RUG. Sometimes, Littre's (penile) and Cowper's (bulbomembranous) glands are seen on normal RUG, but they are usually seen secondary to obstruction. A filling defect at the proximal bulbar urethra due to a contraction of an anterior part of the bulbospongiosus muscle (compressor nuda) can be confused with a USx.

If voiding is achieved, normal findings on VCUG are: bladder neck, and prostatic and membranous urethra are open. Anterior urethra is poorly partially distended and delineation is suboptimal for a proper interpretation.

Tips and Troubleshooting. If the catheter-tip adaptor does not pass through a meatal/fossa stricture during RUG, it can be replaced by an intravenous sheath or one may use a 6-8F pediatric cystoscope or even a ureteroscope. When a subject is not able to void in the context of a bulbomembranous or posterior stenosis/PFUI during VCUG, the bladder neck status (regarding either function or anatomy) cannot be appropriately evaluated, so that, an attempt to ascendingly pass a 6-8F pediatric cystoscope can be done. If available, it might be necessary to perform an antegrade flexible cystoscopy through a SPC tract along with a RUG, simultaneously. If there is no previous tract, an 18F SPC might be placed, so antegrade cystoscopy could be done 3–5 weeks later, to better define the defect length and bladder neck status (incompetence, fibrosis, tethering or non-relaxing). Some simple non-evidence-based maneuvers

may be attempted in case of psychological inhibition to void, e.g., to fill the bladder until the need to void is triggered, to open a water faucet, to play relaxing music, to turn the room's lights off, and/or to place the patient in a standing position (but still

obliquely). In patients with a known BPH, alpha-blockers may be initiated >7 days before VCUG. Information about posterior urethra/bladder neck may be critical in surgical planning and predicting postoperative continence after reconstruction.

Appendix 3

Procedure Description for SUG

Materials. Same preparation than used for RUG is made. Typically, SUG is performed with a linear transducer between 5 and 15 mHz. Urethra is slowly and steadily distended with 20–100 ml of sterile saline or jelly injected using the same materials and in the same fashion as in RUG, excluding air bubbles.

Positioning. Unlike in RUG, either a normal supine, a frog-legged or a low-lithotomy position is used, depending on the stricture length and location.

SUG Scanning. Under cephalad stretching, towards the pubic bone, multiple transverse and longitudinal scans on the ventral penile surface can be taken until length, caliber, location, spongiofibrosis, and coexistent pathology are identified. The same is repeated at the penoscrotal junction (trans-scrotally) for proximal penile and bulbar USx.

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Principles of Urethral Stricture Reconstruction and Its Instrumentation

6

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6.1 Introduction

Urethral reconstructive surgery is a true hybrid of urologic and plastic surgery. The reconstructive urologist therefore must possess intimate knowledge of the anatomy and function of the genitourinary tract and must be familiar with the principles of tissue transfer, graft take and wound healing. An expert hand is also required, as urethral and transferred tissues are very delicate.

In this chapter, surgical principles of reconstructive urology, as well as the principles of wound healing and tissue transfer will be discussed in detail. An overview of the surgical instruments that should be a part of the reconstructive urologist's armamentarium will also be performed.

no harm. As previously mentioned, urethral tissues are very delicate and improper handling may lead to further damage and compromised tissue quality. Attention to detail is imperative throughout the entire period of time that the patient is entrusted to your care. This is valid for the entire pre-operative evaluation and the post-operative course, and not only while your patient is in the operating room.

Nomenclature is important when discussing urethral pathology. A urethral stricture refers to urethral luminal narrowing with associated spongiofibrosis, which occurs in the anterior urethra (distal to the external sphincter). Urethral stenosis (or contracture) is an obliterative, fibrotic process that occurs in the posterior urethra or bladder neck, usually secondary to pelvic fracture urethral distraction (PFUD) injuries or surgery such as radical prostatectomy [1].

6.2 Surgical Principles in Reconstructive Surgery

As a general surgical rule, valid for not only reconstructive urology but for all surgical specialties, the reconstructive urologist must first *do*

6.2.1 Pre-operative Evaluation

A proper pre-operative evaluation is key, as good knowledge of the case will help avoid unexpected surprises in the operating room. While taking the patient's history, knowledge of the mechanism of urethral disease (e.g., straddle injury) may help understand the underlying disease process. Identifying number and type of past treatments will also help plan subsequent procedures, especially if tissue transfer techniques have already been used.

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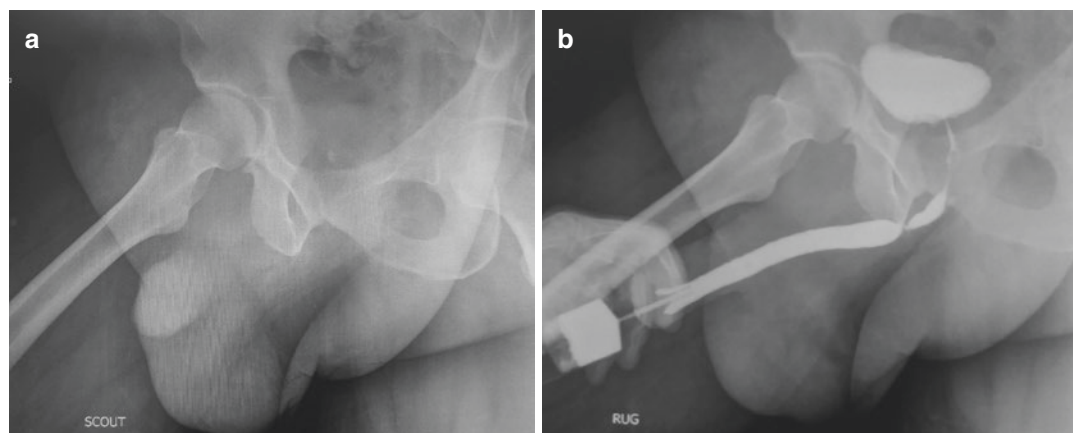


Fig. 6.1 (a) Scout film and (b) retrograde urethrogram showing a bulbar urethral stricture

Pre-operative testing, such as endoscopy and imaging, are also essential components of the pre-operative evaluation. Office flexible cystourethroscopy is quick and easy to perform and allows the urologist to determine the severity of the urethral luminal obstruction, as this may also impact treatment decision. Also, cystoscopy may also rule out *functional* urethral strictures, which means that if the stricture permits the 17-Fr flexible cystoscope to pass, the obstruction caused by the stricture is likely not significant and may not have to be treated. Endoscopy also allows the surgeon to rule out a malignant urethral obstruction, and if the lesion looks suspicious, biopsy is recommended before any reconstructive treatments are commenced.

Radiographic imaging of the urethra, including both a retrograde urethrogram (RUG) and a voiding cystourethrogram (VCUG) is essential prior to reconstructive surgery. The patient must be properly positioned in a modified lateral decubitus position, with the hips placed at a 45° angle, the lower leg bent and the upper leg straight, and the penis must be on full stretch. *If the oblique position is not achieved and the penis is not fully stretched, the length of the stricture will be underestimated.* To ensure that the patient is in a correct oblique position, only one obturator foramen should be visualized on the scout image. For contrast injection, in the authors' practice, a 60 mL catheter-tipped syringe is used, in lieu of a Foley catheter inflated in the fossa navicularis. The

contrast agent must be injected slowly into the urethra to prevent contrast extravasation and patient discomfort, which may cause him to contract his external sphincter and therefore not allow the posterior urethra to fill. Once the RUG is performed and the bladder is full, the patient is instructed to void to perform the VCUG. The McCallum criteria, developed in the 1970s, are still used today to properly perform and read a RUG/VCUG [2] (Fig. 6.1).

In patients that are unwilling or unable to undergo a full endoscopic and radiographic evaluation in the clinic, these procedures may be performed in the operating room as an exam under anesthesia. However, a VCUG cannot be performed in this circumstance. PFUD patients awaiting posterior urethroplasty should undergo a preoperative examination under anesthesia, as estimation of the length of the defect requires an antegrade flexible cystoscopy via their suprapubic cystostomy site, while a RUG is performed simultaneously (Fig. 6.2).

All patients must have a pre-operative urine culture performed. If positive, appropriate treatment must be commenced at least 48 h prior to surgery, chosen according to the antibiogram.

6.2.1.1 Urethral Rest

For anterior urethral strictures, the urethra should not be instrumented for 6–12 weeks prior to the urethroplasty. This allows the scar to mature and declare itself appropriately. In cases of very tight



Fig. 6.2 A combined antegrade flexible cystoscopy with a retrograde urethrogram performed under anesthesia reveals the length of the urethral defect in a pelvic fracture urethral distraction (PFUD) injury patient awaiting posterior urethroplasty

strictures causing significant lower urinary tract symptoms (LUTS) or urinary retention, or a severely dilated urethra proximally to the obstruction, placement of a suprapubic tube (SPT) may be indicated. In these cases, we recommend repeat imaging after the period of urethral rest as the surgical plan may differ once the stricture has fully declared itself [3, 4].

For PFUD, a 3-month period of urethral rest is traditionally recommended before proceeding with posterior urethroplasty, although recent data has shown that a 3–6-week resting period has similar outcomes [5]. More importantly, the reconstructive urologist must ensure that the patient's other injuries have been appropriately addressed, and that the patient is physically able to be placed in the lithotomy position before proceeding to surgery.

6.2.2 Intra-Operative Principles

6.2.2.1 Patient Preparation and Positioning

After proper patient identification and induction of anesthesia, patient preparation for surgery begins. Intravenous antibiotic prophylaxis covering skin

flora and urinary pathogens should be given and adjusted according to the pre-operative urine culture and past resistances if indicated. Proper shaving of the perineum, genitalia and the lower abdomen (in case supra-pubic access is required) should be performed using a straight razor, taking care not to injure the skin [6]. Patient is then placed into lithotomy position and the skin is prepped preferably using an alcohol-based solution, as this is more effective than providing in eliminating skin flora [7]. The pre-operative images should be reviewed and available for consultation in the operating theatre at all times.

The exaggerated lithotomy position allows for excellent access to the perineum for mobilization of the entire urethra and enables two surgeons to work side-by-side with minimal compromise while working via a small incision. Despite its “bad reputation” for increased complication rates, this position has been deemed safe provided adequate equipment and attention to proper positioning are used. The surgical time should also be limited to a maximum of 4 h. Peroneal nerve neurapraxia, manifested by paresthesia or hypoesthesia along the dorsum of the foot, may arise in up to 20% of patients after the exaggerated lithotomy position, however this usually resolves within 48 h [8, 9]. It is the authors' preference to place urethroplasty patients in the exaggerated lithotomy position, however the dorsal lithotomy position is acceptable as well if this is the surgeon's preference or if proper equipment for exaggerated lithotomy is not available (Fig. 6.3).

6.2.2.2 Surgical Equipment

Surgical loupes allow for magnification of the surgical field and proper identification of the very small anatomical structures encountered in reconstructive urology. In the authors' opinion, 2.5 power glasses are sufficient. A headlight is also a useful tool for proper visualisation.

A detailed review of surgical instruments for urethral reconstruction is presented in the final portion of this chapter.

6.2.2.3 Intraoperative Endoscopy

Endoscopy is a very important tool for the reconstructive urologist. Flexible or pediatric cystoscopy should be liberally used throughout the



Fig. 6.3 Exaggerated lithotomy position

case. Evaluation of the urethra proximal to the stricture should always be performed to rule out presence of squamous metaplasia – and, if encountered, the urethral spatulation should be extended until healthy urothelium is reached, to prevent stricture recurrence. The bladder should also be fully inspected to rule out malignancy and bladder stones.

Endoscopic placement of a guidewire may be useful in cases with a very tight urethral stricture, to ensure the urethral lumen is opened along the proper plane.

6.2.2.4 Incision

The choice of incision – midline versus lambda – should be based on surgeon preference. The midline incision allows for adequate visualisation in the majority of cases. A lambda incision may provide increased proximal exposure, especially for complex posterior urethroplasty cases. However, the lambda incision harbours higher dehiscence rates [10] (Fig. 6.4).



Fig. 6.4 Perineal lambda incision

6.2.2.5 Tissue Handling and Visualisation

As mentioned above, the principle *do no harm* is primordial when performing reconstructive surgery. One must handle tissues with caution and care, using delicate movements and fine instruments that do not crush or tear the tissues. The tissue planes must be respected, and meticulously dissected layer by layer. Hemostasis must be quick and precise, as a bloody field limits proper visualisation of surgical planes. Bipolar cautery is preferentially used, to limit thermal damage to the adjacent delicate tissues.

Proper visualisation is key. A good retractor is essential in achieving this, as described in the instrumentation segment of this chapter. Surgical loupes, proper lighting and a knowledgeable surgical assistant are all useful adjuncts in achieving good visualisation.

6.2.2.6 Urethral Calibration

Regular urethral calibration throughout the case will ensure that the entire stricture has been addressed, that the urethra is sufficiently spatulated and will rule out the presence of a secondary stricture. Gentle calibration is performed using bougies-à-boule. The authors aim for a caliber of 30Fr in the bulbar and posterior urethra, and a caliber of 26–28Fr in the penile urethra (Fig. 6.5).

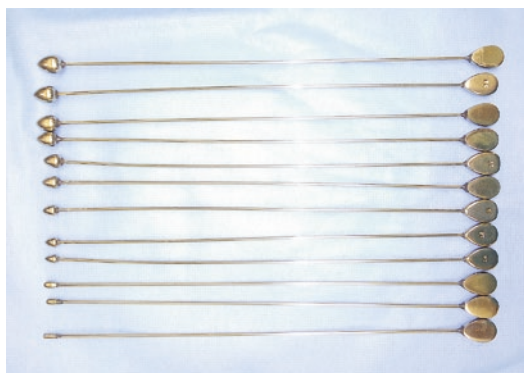


Fig. 6.5 Set of bougies-à-boule sized from 8Fr through 30Fr

6.2.2.7 Urethral Anastomosis

The principles of an anastomotic repair are applicable to urethral anastomoses. The reconstructive surgeon must achieve a (1) *tension-free*, (2) *watertight*, (3) *well-vascularized* and (4) *stented* urethral anastomosis using (5) *resorbable sutures*.

The first step in achieving a *tension-free anastomosis* is *mobility*. Proximally, the entire bulb of the corpus spongiosum is dissected and the central tendon is divided, allowing for mobility of the bulb. Distally, Buck's fascia is dissected off the corpus spongiosum until the penoscrotal junction. Dissection distal to the penoscrotal junction causes chordee. When performing an excision and primary anastomosis (EPA) urethroplasty, corporal splitting allows the urethra to lie in a *straight plane*, shortening the gap. Corporal splitting must not be performed if a grafted anastomosis is necessary. For posterior urethroplasty, infrapubectomy and corporal rerouting may also be necessary when large gaps must be bridged.

To achieve a *watertight anastomosis*, the surgeon must place 8–12 circumferential sutures. The three apical sutures (11, 12 and 1 o'clock) are very important and should be performed at the beginning of the anastomosis. If required, a traction suture at 6 o'clock may be placed before the apical sutures, to aid with visualisation.

The *dual antegrade-retrograde blood supply* to the corpus spongiosum allows a transecting

urethral anastomosis to remain vascularized. However, certain clinical situations – such as anatomic abnormalities like hypospadias, a history of radiation therapy and prior urethral surgery – may warrant a vessel-sparing approach [11]. For patients with PFUD, erectile function *must* be evaluated pre-operatively. If erectile dysfunction following the injury is present, doppler ultrasound evaluation of the corporal arteries is indicated and if injury is present, a revascularization procedure must be performed before proceeding with the urethroplasty.

A small-caliber *urethral stent* must always be placed through the urethral anastomosis. This acts not only as a drainage tube, but also as a wick for blood and urethral secretions. A 14Fr silicone catheter is the authors' stent of choice. If the catheter is placed before completion of the anastomosis, great care must be taken not to suture the stent into place. If a SPT is also in place, it is placed to gravity drainage with a bag, and the urethral catheter is capped.

Finally, as with any suture placed in the urinary tract, the suture of choice must be *resorbable* to prevent stone formation. The authors' sutures of choice are either Vicryl® (Ethicon, Somerville, NJ) or PDS® (Ethicon, Somerville, NJ) on an RB-1 taped needle. Suture size varies between 3–0 and 5–0, depending on the clinical situation.

6.2.3 Post-operative Principles

6.2.3.1 Early Post-operative Care

While in the recovery room, patients should be assessed for leg pain. Leg pain out of proportion to the clinical exam is a clinical sign of compartment syndrome, a rare yet severe complication of lithotomy position. This is more common if the surgical time was longer than 4 h.

The majority of urethroplasty patients can be discharged after a short-stay admission (<23 h), and some centers have been practising same-day surgery for young patients with an uncomplicated surgery [12, 13].

Patients are discharged home with a leg bag for their catheter. If a SPT is also in place, it is placed to gravity drainage with the leg bag, and the urethral catheter remains capped. Patients are taught proper catheter care and instructed to keep the perineal incision dry and clean. Patients are also instructed not to place direct pressure on the perineum until they are seen for post-operative follow-up, and rather to sit in a slouched or reclined position. Anticholinergics may be prescribed to prevent bladder spasms, as well as erection suppression to prevent painful erections in young patients. Antibiotic prophylaxis is not indicated in patients with a negative pre-operative urine culture, but a urine culture should be performed at the time of the voiding trial in clinic.

If a buccal graft was harvested, ice packs are very helpful in limiting swelling of the cheek. Patients may increase diet as tolerated, and are instructed to avoid very hot, spicy and salty foods for the first few days or weeks, as they may irritate the harvest site. Viscous lidocaine and Peridex oral rinse may be used as needed.

6.2.3.2 Long-Term post-operative Care

Patients are seen 3 weeks post-operatively in the outpatient clinic for imaging and a voiding trial. In the authors' practice, the bladder is filled with contrast material via the urinary catheter, then the catheter is removed and a VCUG is performed. Alternately, a peri-catheter RUG may be performed, and the catheter removed if there is absence of extravasation. If a SPT is in place, it is capped and kept in situ for 48 h. If the patient is voiding well, they are instructed on how to remove it at home.

There exists no standardized follow-up protocol after urethral reconstructive surgery. In the authors' practice, the patient is seen 3 months post-operatively for a uroflow rate and post-void residual (PVR). The patient is then seen at 6 and 18 months for a flexible cystoscopy. At this point, the EPA patient is discharged from our care if he is doing well. In the case of a grafted repair, we continue to see the patient yearly with a flow rate and PVR, and a cystoscopy every 2–3 years, or if symptoms recur.

6.3 Principles of Wound Healing

Knowledge of the principles of wound healing is essential for the reconstructive urologist. Understanding the phases and duration of wound healing allows the urologist to predict timing of recovery after urethral surgery and plan subsequent or sequential procedures.

The three phases of wound healing are described as follows [14]:

6.3.1 Inflammation Phase (0 to 3–5 Days)

The initial inflammatory phase begins immediately after hemostasis. After the clotting process is complete, increased local vascular permeability allows for cellular recruitment of neutrophils and macrophages, which clean the wound via phagocytosis and activate a cytokine response. This phase is clinically evident due to erythema and edema.

Infection, foreign bodies and necrosis impede wound healing by prolonging the inflammatory phase.

6.3.2 Proliferation Phase (3–5 Days to 1 Week)

The second stage of wound healing is characterized by proliferation of basal cells and migration of epithelial cells, causing epithelialization. This new epithelium acts as a protective barrier for the wound but provides little tensile strength. Proliferation of fibroblasts also occurs, initiating collagen matrix formation and myofibroblast production, which allows the wound to begin contracting and closing. Stimulated by collagen production, angiogenesis begins in this phase by forming a small network of fine capillaries.

6.3.3 Remodelling Phase (1 Week to 1 Year)

Important increases in collagen production and tensile strength occur during the final phase of wound healing. Cross-linking of collagen fibers

are central to this process. *The scar formed achieves approximately 80% of its tensile strength after 6 weeks.* The scar continues to mature and gain strength for up to 1 year after the injury, however will never fully recover.

6.4 Principles of Tissue Transfer and Graft Take

The term *tissue transfer* implies *harvesting from a donor site and mobilizing it to a recipient site for the purpose of reconstruction.* Knowledge of the anatomy and physiologic properties of both donor and recipient sites is essential, as is the knowledge of the process through which the transferred tissue may survive in its recipient site.

First and foremost, the difference between a graft and a flap must be established. A *graft* implies tissue that is *excised from its donor location and transferred without its own blood supply to a recipient site, where new vascularisation must be formed via a process called take, allowing the graft to survive in its recipient site.*

A *flap* implies that the *tissue is excised and transferred with its own blood supply – either preserved or surgically re-established [15].*

6.4.1 Grafts for Urethral Reconstruction

6.4.1.1 Phases of Graft Take

As mentioned above, take is the process through which the graft creates a new blood supply within its host bed, allowing it to survive in its new environment. Take requires approximately 5 to 7 days and occurs in three phases, (1) *imbibition*, (2) *inosculation* and (3) *revascularisation*.

Imbibition (0–48 h) is the first phase during which the graft directly absorbs nutrients from its host bed. During the second phase, *inosculation* (48–96 h), fine capillaries between the graft and the host bed begin to align, initiating the creation of a microcirculation within the graft. With the last phase, *revascularisation* (5–7 days), the graft is able to survive in its new location due to a completed vascular network.

6.4.1.2 Oral Mucosa Grafts

The oral mucosa harbours multiple favourable characteristics that render it ideal grafting tissue for urethral reconstructive surgery, and it is currently the most common type of tissue used. The buccal, labial and lingual mucosae are all *non-hirsute* surfaces, with a *thick, non-keratinized epithelium*, similar to urethral urothelium. Oral mucosa also possesses a richly *vascular lamina propria*, ideal for graft take. This tissue is also *resilient and easily handled and harvested*, with *minimal donor site morbidity and no cosmetic impact.*

Buccal mucosa graft is the most common type of oral mucosa used and consists of harvesting the mucosa from the inside of the cheek. One can harvest a very large graft from a single cheek, usually up to 5 by 7 cm in size, and mucosa from both cheeks can be harvested if necessary. A few anatomic considerations are important to prevent donor site morbidity; *firstly, Stensen's duct (parotid gland duct) is identifiable as a small yet clearly visible dimple situated adjacent to the second maxillary (superior) molar. Stensen's duct must be clearly marked out and avoided throughout the harvesting process, as injury to the duct may cause obstructive parotiditis requiring subsequent surgical intervention. Secondly, a margin of a minimum of 5 mm must be kept between the outer limit of the graft and the lip, as straying too close to the lip may cause scarring and poor cosmetic results. Finally, when elevating the graft, the surgeon must take care to stay above the masseter muscle. Injury of the master muscle may cause bleeding and increased post-operative pain [16].* Hydrodissection using 0.5–10% lidocaine with epinephrine aids to stay in the right plane while elevating the graft.

Endonasal intubation is not routinely required to harvest buccal mucosa graft, and it is usually sufficient to tape the endotracheal tube to the contralateral side.

Although small donor sites can be closed with resorbable suture, large donor sites should not be closed due to increased risk of post-operative pain, slower return to normal diet and normal mouth opening, and longer duration of bothersome perioral numbness. Instead, complete hemostasis is achieved, and epinephrine-soaked cottonoids are kept in place until the end of the case [17].

Once harvested, the graft must be “de-fatted” with scissors until all the yellow fat is removed and the shiny white surface of the lamina propria is visible. This step is necessary for graft take. The graft is then placed in a marked, saline-soaked gauze and safely kept until ready to use in the urethra (Fig. 6.6).

Labial mucosa grafts typically come from the mandibular (lower) labial mucosa. As mentioned above, care must be taken to stay at least 5 mm from the border of the lip to prevent scarring and poor cosmetic results.

Lingual mucosa grafts are harvested from the lateral sublingual mucosa. Bilateral grafts can be harvested if necessary, leaving the frenulum of the tongue intact at the midline. A strong traction suture through the tip of the tongue aids greatly for mobility of the tongue and visualisation.

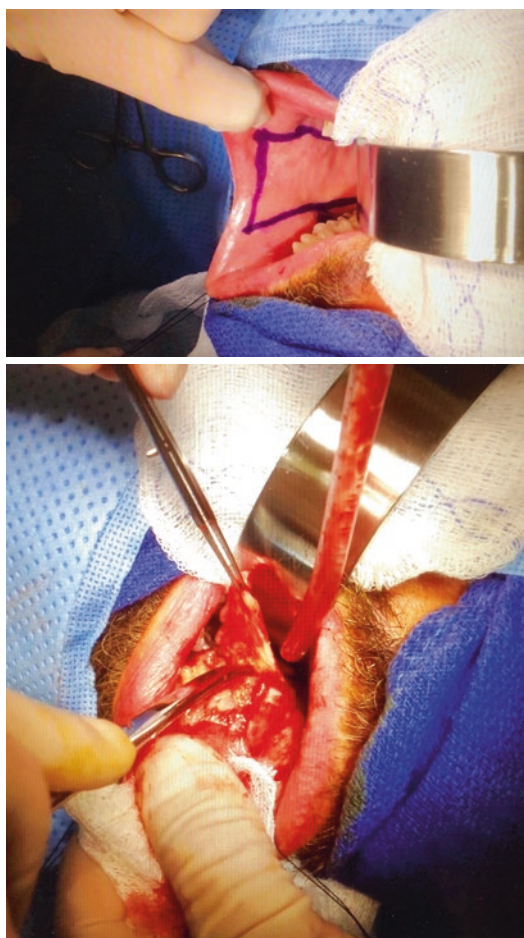


Fig. 6.6 Buccal mucosa graft harvesting

Contrary to buccal and labial grafts, the lingual donor site should be closed with a running, resorbable suture. Bilateral lingual graft harvesting may cause a slightly higher risk of perioral numbness and dysphagia [18].

6.4.1.3 Skin Grafts

The use of skin grafts has largely been abandoned for urethral reconstructive surgery, with the exception of the *Wolfe (postauricular) graft*. This is a full-thickness skin graft harvested from the very thin skin behind the ear. This area has a very rich subdermal plexus and is commonly used for nasal and ocular reconstruction. The donor site is also highly concealable. The Wolfe graft should be considered for patients who no longer have any oral mucosa donor sites available (usually after multiple reconstructive surgeries) or with poor oral hygiene or oral submucosal fibrosis (a disease often caused by chewing tobacco) [19]. Patients of a certain profession, notably singers or air instrument players, may also prefer keeping their oral mucosa intact.

6.4.1.4 Other Types of Grafts

Other types of grafts, such as bladder and rectal mucosa, have been described in the past but are rarely used due to increased donor site morbidity.

6.4.2 Flaps for Urethral Reconstruction

The vast majority of flaps used for urethral stricture reconstruction consist of *skin island flaps*. An island flap implies that the skin is divided, leaving the underlying vascular tissue intact. For urethral reconstruction, the use of *redundant, non-hirsute genital skin* is of the most use, on a pedicle of vascularized Dartos fascia. In uncircumcised patients, the foreskin is typically the best candidate. In circumcised patients, areas of skin redundancy typically close to the circumcision incision may be found and mobilized. The *Jordan flap meatoplasty* is a *transverse ventral island skin flap* and is a perfect example of how penile skin can be used for urethral reconstruction [20]. The only caveat to this technique is that it cannot be used in cases of lichen sclerosus (LS)

as the disease will recur in the penile skin [21]. For very long urethral defects, a longitudinal penile skin island flap can be used.

6.5 Instrumentation for Urethral Reconstructive Surgery

Surgical instruments for urethral reconstructive surgery should be in good condition and receive regular maintenance. Scissors should be sharpened regularly, pickups should be fine with well-maintained tips that do not crush the tissues, and blades should be fresh and sharp. Bipolar cautery is preferentially used as this limits transfer of heat to adjacent tissues. As mentioned earlier the chapter, the use of Bougies-à-boule for urethral calibration throughout the case is essential.

Detailed below is a non-exhaustive list of tools and instruments that the authors find useful in their reconstructive urology practice.

6.5.1 Retractors

6.5.1.1 Jordan-Bookwalter Retractor

This metal ring retractor set is the gold standard for perineal exposure. The hooks and retractors

can easily be clipped on the ring and adjusted throughout the case to maintain exposure and retraction. This retractor is especially useful in cases involving the very proximal bulbar or posterior urethra (Fig. 6.7).

6.5.1.2 Scott Retractor

If a Jordan-Bookwalter retractor is not available, a Scott retractor and its hooks are a good alternative (Fig. 6.8).

6.5.2 Pickups

Although a good pair de DeBakeys can be the mainstay instrument in most urethroplasty cases, the authors like to use the following pickups to ensure delicate tissue handling and good visualisation.

6.5.2.1 Plaque Pickups

Plaques are the ideal pickup for delicate tissue handling of the urothelium, due to the fine multi-toothed tip that gently grasps the urothelium without crushing it. The surgeon must take

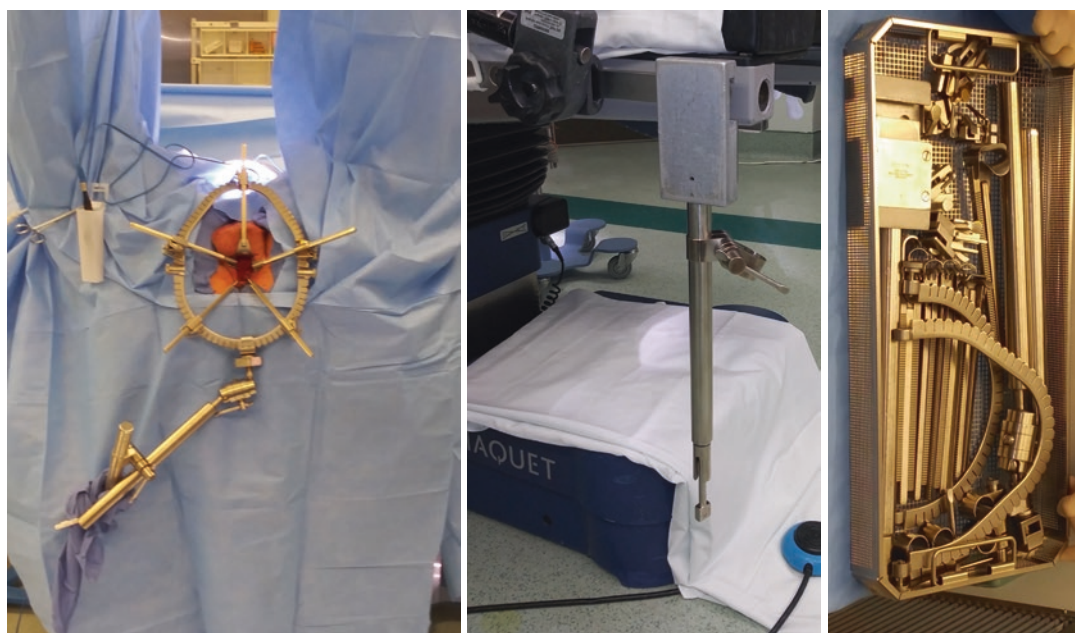


Fig. 6.7 Jordan-Bookwalter perineal retractor system

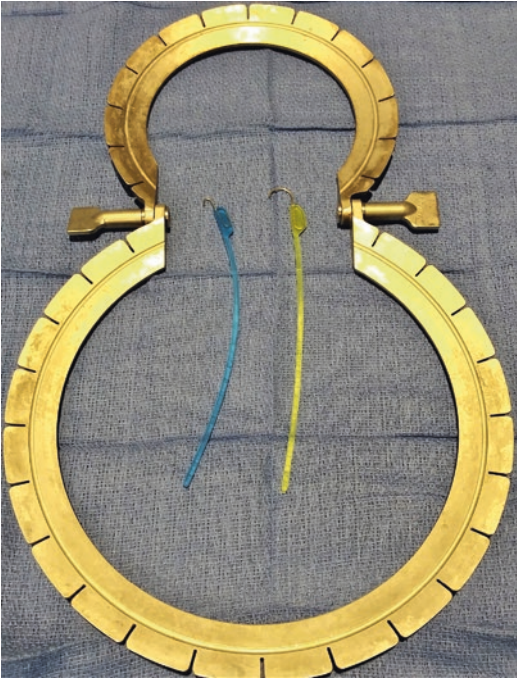


Fig. 6.8 Scott retractor and hooks

care, when suturing, to hold the needle just proximal to the toothed aspect of the pickup, not to dull and excessively wear out these fine pickups.

6.5.2.2 Brown Pickups

These larger multi-toothed pickups are excellent for handling the corpus spongiosum without causing damage. They must not be used on urothelium.

6.5.2.3 Curved-Tip Pickups

Although many reconstructive urologists use a nasal speculum to visual the lumen of the proximal urethra when placing the anastomotic sutures, the authors prefer using a pair of fine curved-tip pickups, as they do not obstruct the surgeons' view as much as the speculum. The tips of the pickups must be dipped in lube before being inserted into the lumen (Fig. 6.9).

Fig. 6.9 (a) Plaque, (b) Brown and (c) curved-tip pickups



6.5.3 Scissors

A good, sharp pair of Metzenbaum scissors are very useful for urethral reconstruction. However, the authors regularly use the following scissors during urethroplasty cases.

6.5.3.1 Par Scissors

Pars are ideal scissors for perineal dissection, as they are very fine and delicate, yet the tip is not too sharp, limiting the risk of injuring the corpus spongiosum.

6.5.3.2 Tenotomy Scissors

These sharp, delicate scissors are used for performing urethrotomy and incising urothelium, as they provide a sharp, clean cut. They must be regularly maintained and sharpened (Fig. 6.10).

6.5.4 Needle Drivers

Delicate needle drivers with a firm grip are essential when handling small RB-1 needles in a narrow perineum. One must ensure the plates of the

needle drivers are regularly maintained so the needle does not turn when it is being handled. The following needle-drivers are especially useful when difficult proximal apical sutures are being placed for the anastomosis, especially for posterior urethroplasty cases.

6.5.4.1 Heaney Curved-Tip Needle Driver

These curved-tip needle drivers provide an excellent hold on the needle and an excellent view when placing anastomotic sutures very proximally, especially in posterior urethroplasty cases (Fig. 6.11).

6.5.4.2 Sarot Needle Drivers

The shanks of this needle driver curve inward, allowing for more manageable suture placement with reduced wrist rotation, which is very useful when placing sutures in a very proximal, tight space.

6.5.4.3 Neivert Needle Driver

The angled – or offset – ring handle of this needle driver allows for a more natural and comfortable grip for the surgeon, when performing delicate suturing (Fig. 6.12).

6.5.5 Tools for Buccal Mucosa Graft Harvesting

To harvest a buccal mucosa graft (BMG), the instruments should be prepared on a second side table, such as a Mayo stand, as the mouth is not



Fig. 6.10 Tenotomy (left) and Par (right) scissors



Fig. 6.11 Heaney needle driver



Fig. 6.12 Neivert needle driver



Fig. 6.13 Mayo stand for buccal mucosa graft harvest

considered sterile and all instruments used for harvesting the graft should not be reused in the perineum.

Listed below are the essential instruments and supplies that the authors use for harvesting a BMG (Fig. 6.13).

- Bite block
- Retractor (tongue retractor or baby Deaver)
- Suction
- Stay sutures (3–0 silk) and mosquito clamps – for lip retraction
- Marking pen – to mark circumference of donor site and Stensen's duct
- 1% lidocaine with epinephrine, 10 mL syringe and 22G needle – for hydrodissection and hemostasis
- 15-blade scalpel

- Fine toothed forceps (such as toothed Gerald's)
- Tenotomy scissors – to elevate the BMG
- Bipolar cautery
- Gauze and cottonoids

Key Summary Points

- The application of principles of reconstructive urethral surgery through all phases of patient care are essential for optimal functional outcomes
- A good quality pre-operative retrograde urethrogram, ideally performed by the treating surgeon, should be performed with the patient in oblique position and penis on stretch to adequately evaluate the length, location and severity of the stricture
- The five principles of urethral anastomoses should always be applied during urethroplasty: (1) tension-free, (2) watertight, (3) well-vascularized, (4) stented urethral anastomosis using and (5) resorbable sutures
- Knowledge of the three phases of wound healing, (1) imbibition, (2) inosculation and (3) revascularization is essential when using tissue transfers during urethral reconstructive surgery

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Tissue Transfer Techniques in the Management of Urethral Stricture Disease: Flaps and Grafts

7

Joel Gelman and James Furr

7.1 Introduction

In the management of urethral stricture disease, substitution urethroplasty is a common procedure, especially in the management of longer strictures, in the setting of prior surgery, or in patients with prior hypospadias repair. Substitution tissue generally falls into two categories: flaps and grafts. Flaps refer to tissue transferred with its native blood supply intact on a pedicle. In contrast, grafts refer to tissue detached from its donor site and transferred to a recipient bed, where the establishment of a new blood supply is needed for graft “take.” This process of revascularization occurs in two steps. The first phase of graft take is imbibition, the direct diffusion of nutrients from the recipient bed across an osmotic gradient. This phase lasts approximately 24–48 hours and is followed by inosculation, which is the eventual neovascularization and capillary ingrowth between the graft and the host recipient bed. Inosculation takes several additional days.

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7.2 Anatomy

Intimate knowledge of the blood supply of the penile skin and urethra are necessary for the successful use of tissue transfer techniques during urethral reconstruction. Additionally, an understanding of urethral anatomy allows the surgeon to choose the best tissue transfer technique depending on stricture length and location.

The normal urethra has dual arterial blood supply, which include paired bulbar arteries that enter the proximal bulbar urethra and provide a major blood supply to the corpus spongiosum. In addition, the paired dorsal arteries of the penis provide a major blood supply to the glans penis along with retrograde flow to the corpus spongiosum. Although there are also perforating vessels between the corporal bodies and the corpus spongiosum, this is a minor contribution, and therefore the normal corpus spongiosum can be mobilized along the entire penile and bulbar urethra without ischemia.

The glans and fossa navicularis represent an expansion of the corpus spongiosum with extension distal to the corporal bodies where in contrast to the penile and bulbar urethra, circumferential mobilization is not possible. In the penile and distal to mid bulbar urethra, the dorsal and ventral aspects of the corpus spongiosum have similar caliber, whereas more proximally in the bulbar urethra, the corpus spongiosum becomes considerably more robust ventrally.



Fig. 7.1 Axial fasciocutaneous versus random skin flaps

The penile skin receives blood supply from branches of the superficial external pudendal artery entering at the base of the penis as posterolateral and anterolateral axial branches. They form an arterial network within the dartos fascia with an axial distribution. This allows penile skin flaps to be raised on this fascial layer with a reliable blood supply; hence they are referred to as fasciocutaneous flaps. When developing penile skin flaps, it is important to preserve the lateral and base aspects of the flaps, as the blood supply passes from lateral to medial from the base of the penile shaft. In contrast, when fasciocutaneous penile skin flaps are elevated for use in hypospadias repair or reconstruction, the remaining blood supply to the penile skin is from a superficial subdermal plexus with a random distribution (Fig. 7.1). As a consequence, if a re-do penile skin flap repair is performed, the blood supply to the flap is random and less reliable, increasing the risk of ischemic stricture recurrence in addition to penile skin deficiency. The repeated use of flaps can be associated with considerable skin loss along with stricture and this condition has often been called “hypospadias cripple” (Fig. 7.2).



Fig. 7.2 Patient with history of hypospadias and multiple surgeries with recurrent stricture and significant skin loss

7.3 Substitution Material Options

There are numerous choices in graft material for use in urethral reconstruction. The use of a penile skin patch graft for one-stage urethral reconstruction was first published in 1953 as a case report by Presman [1]. In 1961, Devine

began to develop a series of patch graft repairs. Then, in 1976, Devine published their 15 year experience with one-stage patch graft urethroplasty [2]. The use of grafts were popular and often preferred for substitution urethroplasty until 1980 when Duckett described the use of a transvers preputial island technique for hypospadias repair, and Quartey subsequently reported the use of a cutaneous island flap urethroplasty for the treatment of urethral strictures [3, 4]. The Quartey paper was a landmark contribution as this represented the first publication that described the fasciocutaneous blood supply of the penile skin flap, which permitted the wide mobilization of the skin for reconstruction anywhere from the external meatus to the prostatic urethra. In 1989, Schreiter described a 2-stage technique using split thickness skin grafts (STSG), which represented an excellent new option for the treatment of recurrent strictures when sufficient penile was

not available [5]. However, the use of flaps remained a favored tissue transfer method when adequate penile skin was available. This was further supported by papers describing the use of ventral penile skin flaps for reconstruction of fossa navicularis strictures with a very high success rate, and the use of circular fasciocutaneous penile flaps to repair extensive long strictures in 1-stage [6].

In 1980, Monseur described incising the urethra along the dorsal surface and fixing the opened edges of the urethra directly onto the corpora cavernosa. The urethra was then allowed to heal via secondary intention [7]. This technique was then modified by Barbagli, who combined Devine's use of free grafts with Monseur's dorsal urethrotomy by placing quilting a graft to the corpus cavernosa to fill the defect [7–9]. He then closed the edges of the dorsally incised urethra to the edges of the graft. This allowed the dorsal graft to be mechanically supported by the corpora cavernosa in addition to providing good vascular supply.

In recent years, buccal mucosal grafts (BMG) have become favored over penile skin and other graft materials [10]. This shift back to the use of graft repairs is likely due to a number of favorable characteristics of buccal mucosa. The graft is readily available, easily harvested, and can cover a large defect when bilateral grafts are taken. The donor site scar is concealed, and BMGs have been known to have low postoperative complications and good patient satisfaction [11]. Some studies have suggested that postoperative pain is improved with non-closure of the graft harvest site, further simplifying the harvest process [12]. Additionally, oral mucosa has favorable vascular characteristics, including a robust elastin-rich epithelium and a highly vascular lamina propria. This rich submucosal plexus facilitates the inosculation needed for graft take. Oral mucosa is also hairless, has an epithelial surface that is well suited to a “wet” environment.

Other oral mucosal options available in the armamentarium of the reconstructive urologists include lower lip grafts and lingual mucosal grafts. Lower lip grafts have excellent surgical access but have been noted to have increased morbidity compared to buccal mucosal grafts that is likely related

to long-lasting neuropathy of the mental nerve [13]. In a study of 40 patients undergoing either lower lip, inner cheek, or both grafts, Jang et al. noted that patients undergoing lower lip grafts had increased persistent postoperative discomfort, neurosensory deficits, and salivary flow changes compared to inner cheek harvest site [14]. As such, there is a tendency to favor inner cheek grafts over lower lip grafts when possible.

Lingual grafts are known to have similar histology compared to buccal mucosal grafts and thus have similar advantages. Additionally, lingual grafts can be harvested from one side of the tongue across the midline in continuity, allowing surgeons to achieve longer lengths than available with buccal mucosa grafts.

7.4 Technique Selection

Selection of the appropriate technique for a patient is a highly individualized process that depends on multiple factors. The ideal repair will depend on stricture location, length, presence or absence of healthy penile skin, and whether or not the corpus spongiosum is intact. Incorporating all of these factors is a complex process, but the proper selection of tissue transfer technique is crucial for success. Our aim is to provide a logical, easily comprehensible approach to the appropriate technique selection in urethral reconstruction.

7.5 Tissue Transfer Techniques to the Glans and Fossa Navicularis

An algorithmic approach to glans and fossa navicularis strictures is outlined in Fig. 7.3. When strictures are truly limited to the glans penis alone (meatal stenosis), a simple or extended meatotomy is the minimally invasive procedure of choice [15]. If the stricture extends further either into the fossa navicularis or is limited to the fossa navicularis, an extended meatotomy continues to represent a simple definitive treatment option that is generally curative as opposed to periodic dilations, which represent a

Fig. 7.3 Algorithm for approach to glans and fossa navicularis strictures. Regardless of the status of the penile skin, extended meatotomy is always a reasonable option if definitive reconstruction is deferred by the patient

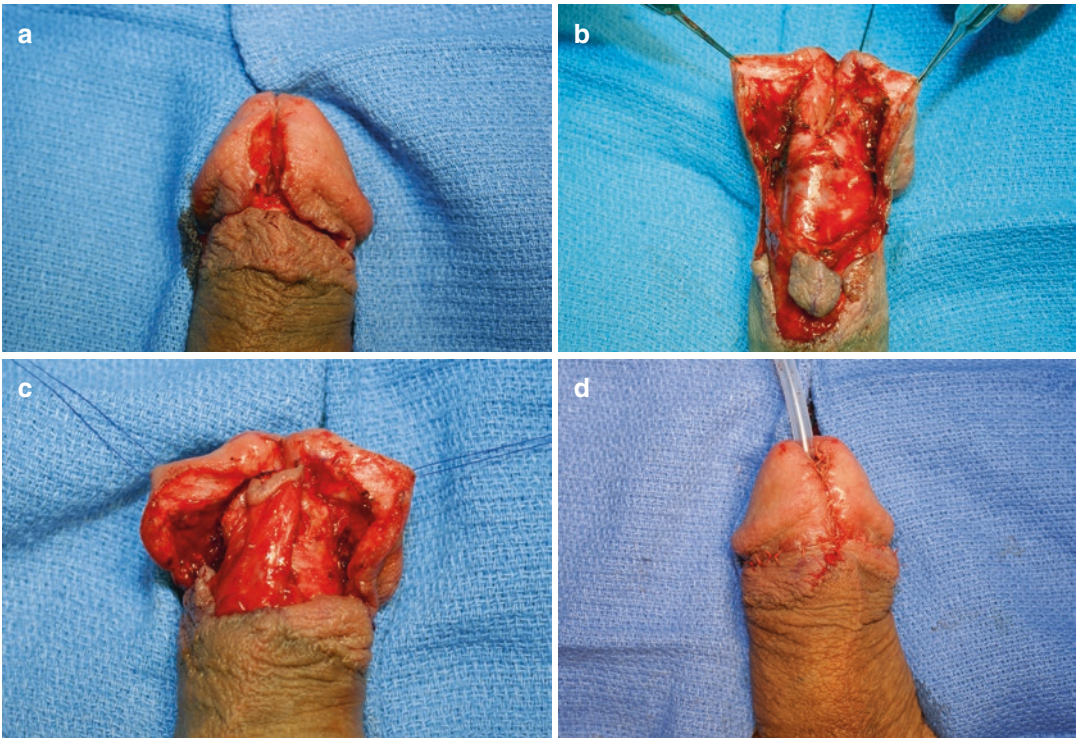
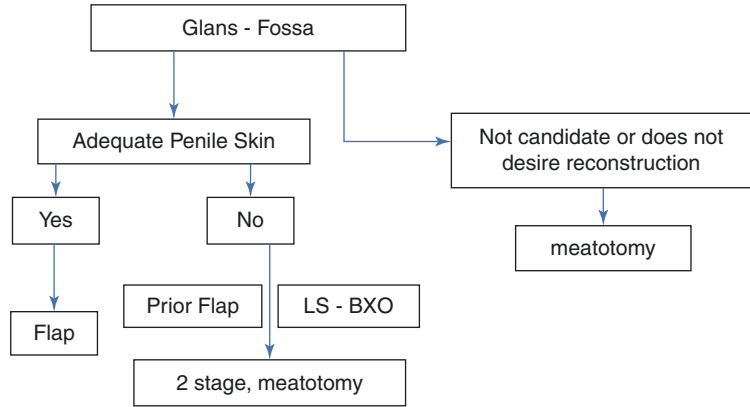


Fig. 7.4 Staged urethroplasty with buccal mucosal graft performed for a patient with a fossa and penile urethral stricture. (a) An extended meatotomy is made through the stricture. (b) BMG quilted on both sides of the opened

urethral plate. (c) The ventral flap has been rotated as a ventral onlay to cover the defect. (d) Immediate appearance after closure

management approach. However, as the stricture extends proximal to the meatus, the extension of the meatotomy will be associated with an elongation and ventral displacement of the urethral opening. A one-stage flap repair is a good option, provided the skin is healthy and adequate and there has been no prior flap surgery that would compromise the use of penile

skin. In these cases, we prefer to use a one-stage ventral transverse island fasciocutaneous penile flap as described by Jordan [16]. After a ventral incision through the stricture, a transverse island penile skin flap is elevated on a broad dartos pedicle and inverted onto the defect prior to closure of the glans wings (Fig. 7.4). Due to the relative laxity of penile skin, this flap can be

used even in circumcised patients. This procedure has excellent long-term success rate with a reported stricture-free rate of 100% among patients who had no lichen sclerosis (LS) also known as Balanitis Xerotica Obliterans (BXO), but a 50% recurrence rate in those with LS [17]. This is not surprising. Bracka and Mundy both nicely demonstrated that the use of penile skin in patients with LS for urethroplasty is associated with a very high late recurrence rate, and this report caused a shift away from the use of

flaps in favor of graft repairs when the skin is not healthy due to a diagnosis of LS [18, 19]. Therefore, in patients with LS or an unreliable penile skin blood supply due to prior flap surgery, our preference is staged graft repair (Fig. 7.5). While our early experience favored the use of STSG, we now exclusively use buccal mucosa grafts for these staged repairs.

There have been recent reports of one-stage buccal graft repairs of glans or fossa navicularis strictures BMG [20, 21]. Chowdury et al.

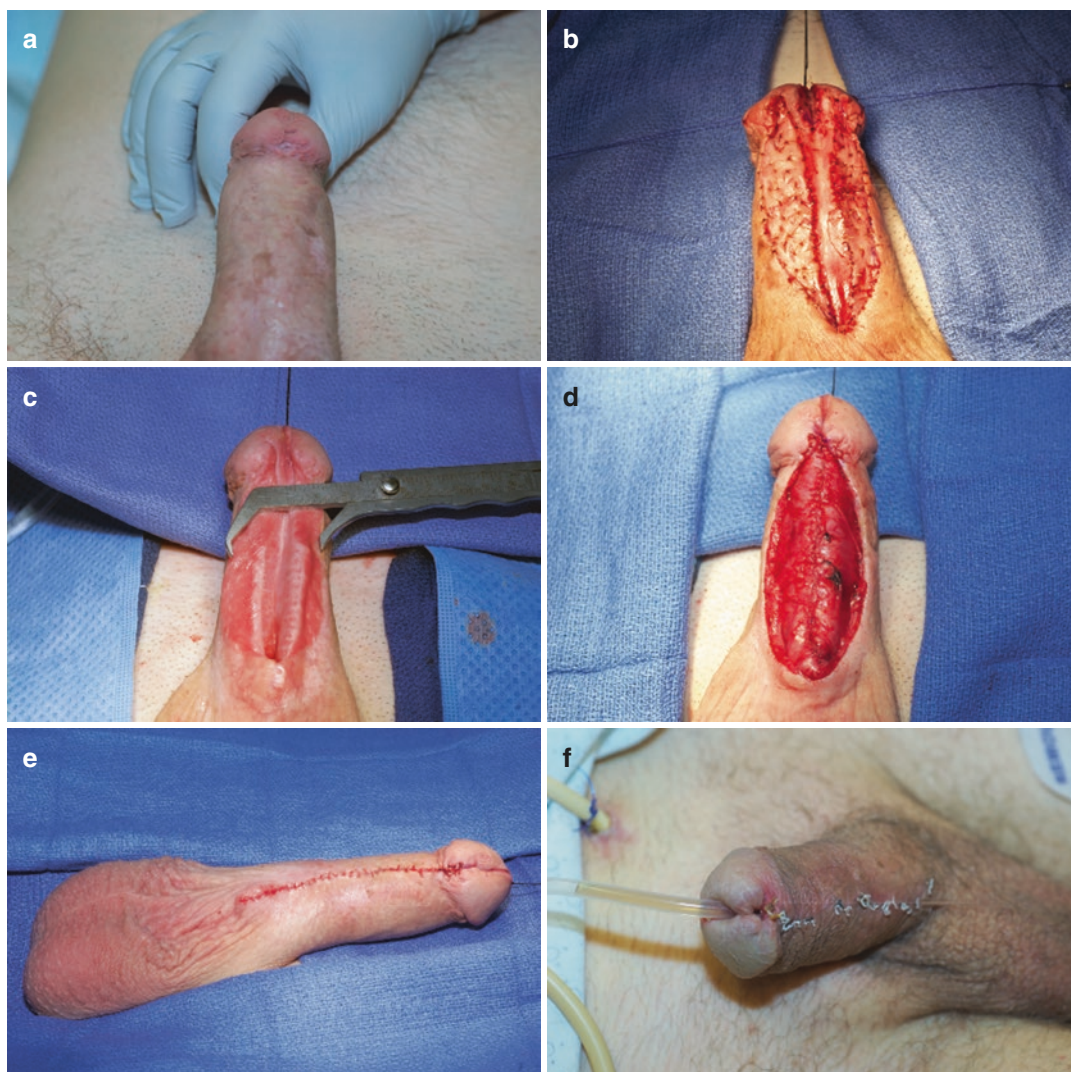


Fig. 7.5 Staged urethroplasty with buccal mucosal graft performed for a patient with a fossa and penile urethral stricture. (a) Demonstration of inadequate penile skin. (b) BMG quilted on both sides of the opened urethral plate.

(c) The urethral plate after 4–6 months of healing from the first stage procedure. (d) Tubularization of the new urethral plate. (e) Appearance immediately postoperatively. (f) Appearance 3 weeks postoperatively

described the use of ventral onlay buccal mucosal grafts using the glans wings as graft beds [20]. Certainly it would be advantageous to repair these strictures with a 1-stage approach. However, we do not believe that these techniques in our hands obtain the same caliber of patency (24–30 French) that can be achieved with ventral flaps (when appropriate) or staged repairs.

Distal strictures in patients with either LS or prior hypospadias repairs represent a challenge to reconstructive urologists where careful selection of repair type and tissue substitution choice can significantly affect long term outcomes. Most importantly, it should be emphasized that the priority of repair is relief of obstruction. Thus, the caliber of the repair, regardless of technique, should not be compromised by aggressively attempting to bring the meatus all the way to the tip of the glans.

7.6 Tissue Transfer to the Penile Urethra and Bulbar Urethra

The repair of penile and bulbar urethral strictures that are not amenable to anastomotic urethroplasty can be performed in one-stage with flaps or grafts, or staged procedures. Decision making regarding repair type depends largely on whether the corpus spongiosum is intact and whether there is sufficient penile skin, as summarized in the algorithm in Fig. 7.6.

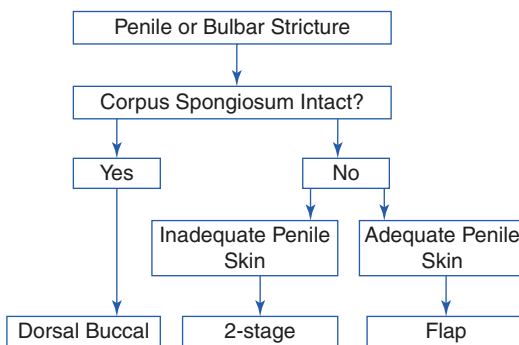


Fig. 7.6 Treatment algorithm for strictures of the penile and bulbar

7.6.1 When the Corpus Spongiosum is Intact- Penile and/or Bulbar Urethra

In patients with intact corpus spongiosum without LS, one-staged procedures are preferred [22]. Overall, the consensus of the current literature provides evidence that buccal mucosa grafts are superior to flaps for 1 stage penile and bulbar stricture repair. Moreover, the use of dorsal grafts preserves the corpus spongiosum ventrally and laterally, essentially eliminating the risk of urethrocutaneous fistula formation, and the support of the urethra by the corporal bodies dorsally and the corpus spongiosum laterally and ventrally prevents the development of diverticular change, and may reduce the risk of false passage should catheterization be indicated as some future time. Although we favor dorsal grafting in both the penile and bulbar urethra, some authors prefer a ventral approach, as it limits the need for urethral mobilization and allows preservation of cavernosal-spongiosal perforating arteries [23, 24]. Additionally, the ventral approach is often considered less technically challenging with shorter operative times [24, 25].

There are some disadvantages associated with ventral placement of BMG. Since the ventral aspect of the bulbar urethra is more robust and highly vascular, some surgeons note increased blood loss at time of surgery with a ventral urethrotomy [26]. Additionally, there is a risk of urethral sacculation or fistula development due to decreased support of the urethra compared to dorsal graft placement.

The dorsal onlay approach offers several advantages over the ventral onlay approach. The graft can be spread fixated to the corpora cavernosa, which is a consistently reliable graft recipient bed. Additionally, the spread-fixation, which cannot be accomplished with the ventral approach, maximizes the surface area of the graft in direct contact with the vascular bed [22]. This optimizes the conditions for graft take and provides up to 2+ cm widening of the urethral plate. It is unclear from the literature whether one technique is superior to the other. No randomized controlled trials comparing the dorsal and ventral onlay BMG urethroplasty exist.

Numerous modifications to the original dorsal onlay graft have been described. For example, in 2001, Asopa et al. described the use of a ventral and dorsal urethrotomy with subsequent placement of an elliptical dorsal inlay graft via the exposure achieved from the ventral urethral incision prior to ventral urethrotomy closure for anterior stricture repair [27]. It allows for spread-fixation of the BMG dorsally with a reliable vascular bed while maintaining advantages of ventral onlay grafts by minimizing urethral mobilization and preservation perforating vessels. However, this technique requires the urethra to be incised both dorally and ventrally.

Kulkarni et al. modified the dorsal onlay procedure in cases of panurethral stricture disease secondary to LS by using a perineal approach, inverting the penis, and extending the dorsal onlay into the fossa navicularis to repair these long strictures in 1-stage [21].

Each of these options has advantages and disadvantages that can be applied in certain clinical scenarios. Until a higher level of evidence emerges, it is our practice to preferentially use the dorsal onlay approach for the advantages mentioned above.

7.6.2 When the Corpus Spongiosum is Not Intact

In some scenarios, the corpus spongiosum is not intact. In patients with hypospadias, the distal corpus spongiosum is often poorly developed and not amenable to circumferential mobilization. Thus, in these cases, a one-stage graft is not recommended [22]. In addition, when there has been prior dorsal graft reconstruction, circumferential mobilization of the corpus spongiosum would detach the buccal graft from its recipient bed blood supply. When there has been a prior flap, circumferential mobilization would likely devascularize the flap. In these cases, if the penile skin is not affected by LS and there has been no prior flap surgery, a fasciocutaneous penile then a skin flap is an option for one-stage repair. When there is a paucity of healthy skin (patients with prior hypospadias or LS), then use of a penile skin flap is contraindicated.

Historically, skin grafts were initially used for staged procedures with a success rate of approximately 50% [28]. With the increased use of BMG graft, the success rate has increased to 80% [29]. Similarly, our presented but currently unpublished institutional data noted an overall success rate of 81.6% in our series of 49 patients undergoing staged urethroplasty with mean follow-up of 32 months. During subset analysis, patients treated exclusively with BMG had higher success rate compared to those who had STSG (100% vs. 64%, $p < 0.01$). Thus, when possible, we preferentially use BMG during staged repairs.

7.7 Special Situations

7.7.1 Augmented Anastomosis

In some cases, there is a segment of obliterated or near-obliterated urethra associated with significant spongiofibrosis. If the stricture is too long to be amenable to excisional repair, an augmented anastomosis can be considered. It is especially favorable if there is wider stricture adjacent to a shorter obliterative segment. After excision of the obliterated stricture, a dorsal mucosal anastomosis with a placement of a flap or graft to augment the ventral urethral wall can be performed. The graft can also be placed as a dorsal onlay with re-anastomosis of the ventral urethral mucosa [30, 31]. More contemporary series have reinforced the efficacy of the augmented anastomotic urethroplasty with success rates >90%, though studies have heterogeneous follow up and definitions of success [32–34].

7.7.2 Graft/Flap Combination

In patients with an obliterative segment and/or significant spongiofibrosis, strictures can be managed with the combined use of dorsal onlay BMG to augment or replace the inadequate urethral plate, followed by a penile skin flap ventral onlay reconstruction (Fig. 7.7). This was first described by Morey in 2001 in four patients with long penile urethral strictures who required BMG ($n = 3$) or

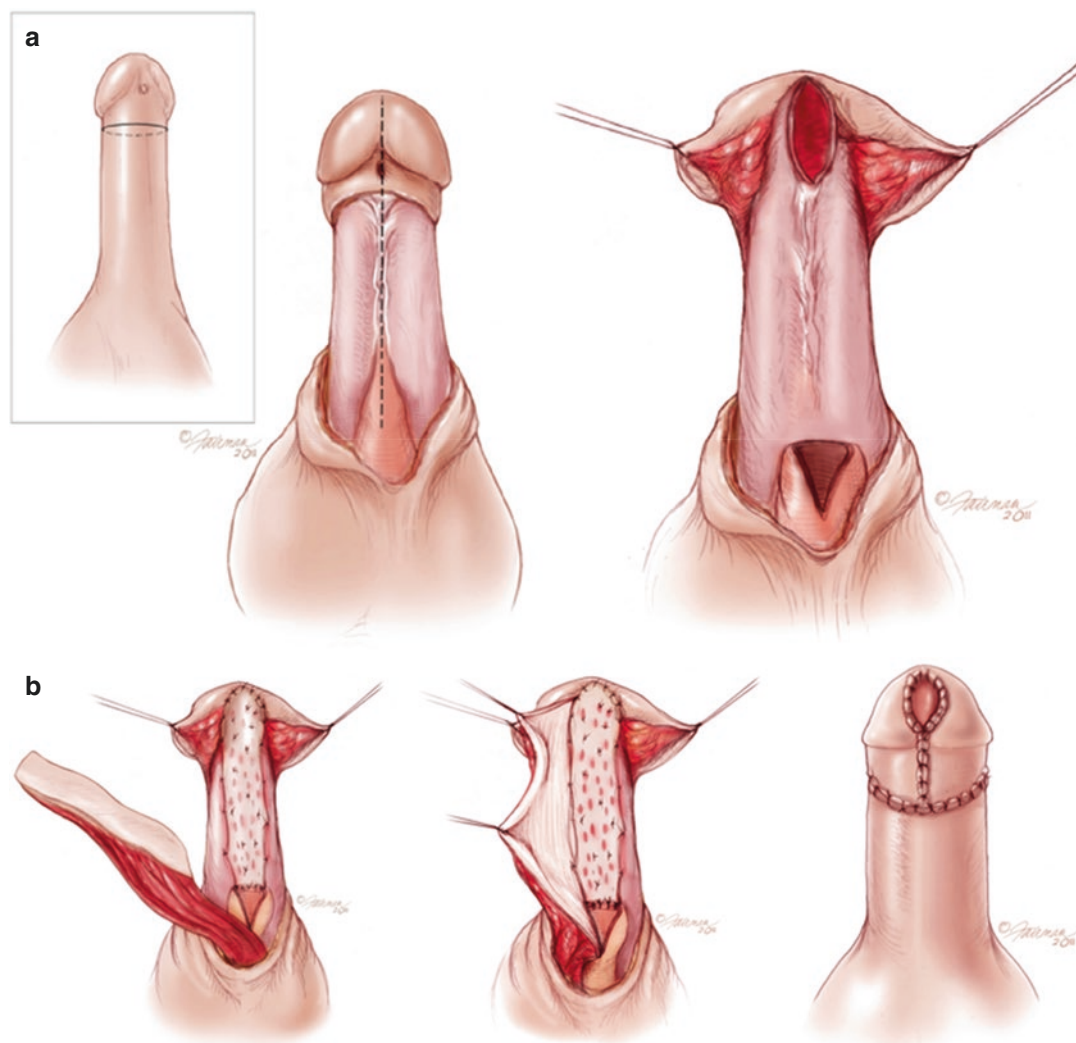


Fig. 7.7 Graft/flap combination. (a) The obliterated urethra is incised proximally until healthy, widely patent urethral lumen is encountered. (b) The BMG is spread fixated to the corpora cavernosa. Then a penile skin flap is rotated

ventrally onto the graft to create a new lumen. In cases where there is a deficiency of urethra within the fossa and a lack of a groove within the glans penis, a defect is created and the BMG is extended into the glans

cadaveric dermal graft ($n = 1$) to augment or replace the urethral plate [35]. Patients then underwent simultaneous transverse penile island ventral onlay skin flap. This allowed for repair in a single stage while avoiding the poor results of single-stage tubularized flaps or grafts for circumferential tissue transfer reconstruction. A larger series was described by Gelman et al. in 2011 with 12 patients with distal urethral strictures who

underwent combined dorsal onlay BMG with ventral onlay penile skin flap [36]. Most patients had hypospadias or recurrent strictures that increased complexity of stricture repair, but a 92% success rate was observed as defined by wide patency at 4-month cystoscopy with subsequent mean follow-up of 39 months.

The combined use of flap and graft can also be used for long panurethral strictures that are too

long to be repaired with BMG, even if bilateral grafts are harvested. Berglund and Angermeier described a series of 18 patients who underwent a combined graft/flap repair for complex strictures with a mean length of 15.1 cm [37]. They were able to achieve an 83% success rate at last follow-up.

7.7.3 Combined Dorsal/Ventral Buccal Grafting

This was first described via a ventral approach by Palminteri et al. in 2008 when he used the Asopa technique to make a ventral urethrotomy with placement of dorsal onlay BMG into the incised dorsal urethral plate and subsequent placed additional graft as a ventral onlay [38]. He noted very good success rate of 89.6% at mean follow-up of 22 months in 48 men. Further long-term follow up of 166 patients undergoing dorsal plus ventral oral graft (DVOG) showed 89.8% success at median follow-up of 47 months, with 90% of failures occurring in the first 5 years [39]. Additionally, postoperative sexual function as determined by validated questionnaire noted preservation of sexual function in all patients with preoperative sexual function [40].

However, Palminteri's technique relies on sufficient urethral plate to perform an Asopa

procedure. Some surgeons have suggested that a urethral plate <1 cm should be a contraindication to performing an Asopa, and thus, a Palminteri DVOG [41]. In 2014, Gelman et al. published a technique targeted towards obliterative urethral strictures [42]. He presented a series of 18 patients with obliterative or near-obliterative bulbar urethral strictures who underwent a combined ventral and dorsal buccal grafting for a single stage repair via a dorsal approach. The technique, currently referred to as a double faced buccal urethroplasty, differed in that the urethra was mobilized and a dorsal urethrotomy was made without ventral incision of the urethra, thus preserving the continuity of blood supply within the spongy tissue. BMG was then quilted dorsally onto the corporal bodies. After excision of obliterated urethral scar, additionally BMG was quilted ventrally through the dorsally incised urethtomy onto the corpus spongiosum in continuity with the distal and proximally spatulated urethra. The dorsal and ventral BMG segments were then approximated, completing the repair (Fig. 7.8).

Some advantages of the repair described by Gelman et al. are that the robust ventral spongiosum is left intact. Additionally, dorsal onlay grafts can be spread-fixed to the corpus cavernosum, which are a reliable vascular bed for the graft. With mean follow-up of 50 months, patients undergoing this repair had a 94% success rate [42].

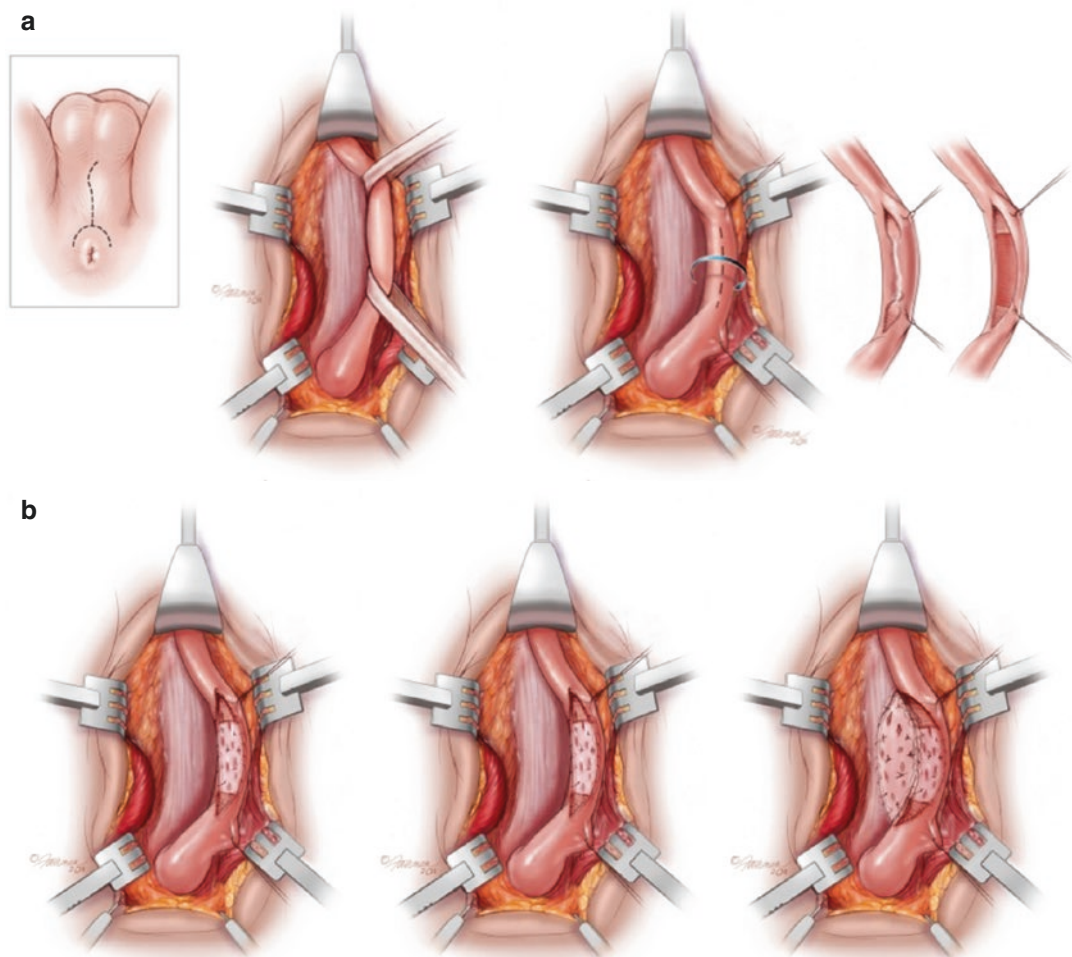


Fig. 7.8 Dorsal and ventral buccal graft combination. (a) The urethra is mobilized and incised dorsally. Fibrotic scar is removed until healthy ventral spongiosum is exposed. (b) BMG is spread fixated ventrally to the spon-

giosum where the obliterated segment was located in continuity with the native mucosa. Additional BMG is then dorsally quilted to the corpora cavernosa before the edges are reanastomosed for tubularization

7.8 Summary

Tissue transfer techniques with flaps and grafts serve as an indispensable tool in the armamentarium of reconstructive urologists. Familiarity with a large variety of techniques and tissue transfer types allow urologists to tailor their repair based on stricture location, stricture length, amount of viable native mucosa, and whether the corpus spongiosum is intact. While there is no clear consensus on a single superior method based on the literature, all techniques mentioned are successful in the appropriately selected patient.

Key Summary Points

- Over time, there has been a transition from penile skin grafting to penile flaps, then most recently to the use of buccal mucosal grafting.
- The ideal technique will depend on stricture location, length, presence or absence of healthy penile skin, and the status of the corpus spongiosum.
- For distal meatal and fossa navicularis strictures, staged repairs with graft are preferred over flaps when lichen sclerosus is present.

- Multiple techniques exist for placement of buccal graft in penile and bulbar strictures, each with its own advantages and disadvantages.
- While there is no clear consensus on a single superior method based on the literature, all techniques mentioned in this chapter are reported to be successful in the appropriately selected patient.

Conflicts of Interest There are no conflicts of interest.

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Surgical Management of Fossa Navicularis and Distal Urethral Strictures

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8.1 Introduction

The management of fossa navicularis (FN) and distal urethral stricture remains a challenge for both general and reconstructive urologists. The goals in treatment of these repairs involve creating a patent distal urethra which is also aesthetically pleasing. Three major barriers exist in the development of a standard surgical approach of the distal strictures: they are difficult to image, to diagnose, and to treat. Furthermore, as with most reconstructive urological interventions, the assessment of surgical and patient-reported outcomes by randomized control trials is lacking. As such, most data supporting one approach over another is usually drawn at best through prospectively collected, but retrospectively designed observational studies. The goal of this chapter is to outline the evolution and treatment of fossa navicularis and distal urethral strictures (Table 8.1).

8.2 Etiology of Distal Strictures

The most common etiologies of distal urethral strictures have significantly changed over the previous three decades. In the past, the most

common causes were attributed to infectious urethritis. However, contemporary series demonstrated that the majority of the strictures are currently a result of iatrogenic causes (such as traumatic catheter or endoscopic injury) or lichen sclerosus [1, 2]. Distal and fossa navicularis strictures are found to comprise approximately 18% of all anterior urethral strictures [2]. Due to the central location within the urethra covered by a thin layer of corpus spongiosum the distal urethra and fossa navicularis are particularly susceptible to stricture formation from trauma and iatrogenic causes [3]. Rates of stricture due to surgical instrumentation ranges from 6% to 31% [1–3]. The main culprits in the development of these strictures are thought to be urologic procedures and instrumentation of the urethra. Additionally, the distal urethra and fossa navicularis are prone to inflammatory conditions such as lichen sclerosus as well as a variety of ischemic processes secondary to their distal anatomic location [4]. Genital and preputial skin changes can progress towards glans and meatus and lead to meatal stenosis [5]. This can then lead to inflammation or infection of the periurethral glans proximally due to high pressure voiding from the meatal stenosis, thus allowing a retrograde progression of the disease through the anterior urethra [6].

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Table 8.1 Fossa navicularis and distal urethral stricture repair techniques

Year	Author	Technique	# of patients	Average follow up (months)	Success	Complications
1963	Cohney, et al.	Fascioutaneous penile skin flap	1	6	6 (100%)	None
1967	Blandy, et al.	Ventral penile U-shape flap	12	Not reported	12 (100%)	Stream deviation
1976	Brannen, et al.	Ventral penile skin flap with inversion	7	6–18	7 (100%)	Stream deviation
1984	De Sy, et al.	Island advancement flap with ventral glans closure	5	NR	90%	None
1987	Jordan et al.	Ventral transverse preputial island flap	5	6–27	5 (100%)	None
1998	Armenakas, et al.	Glans cap with tunneled neourethra	19	42.7	18 (94%)	None
1998	Venn and Mundy	(a) Stricturotomy and pedicled penile flap	(a) 16 non genital skin flap	12–36	(a) Non genital skin flap: 15 (93%)	NR
		(b) Stage free-graft urethroplasty with BMG in BXO patients	(b) 12 genital skin flap		(b) Genital skin flap: 0 (0%)	
2007	Virasoro et al.	Ventral transverse skin island flap elevated on a dartos fascia flap	35	10.2 (years)	Intact glans sensation post op	1 patient with fistula
2007	Morey et al.	(a) Penile fasciocutaneous skin flap technique with glans cap preservation	(a) 11	52	(a) 10 (91%)	NR
		(b) Ventral buccal mucosal graft onlay	(b) 13		(b) 7 (54%)	
		(c) Extended meatotomy	(c) 16		(c) 14 (88%)	
2009	Goel et al.	Double buccal ventral and dorsal grafts	10	13.5	10 (100%)	Urine spraying
2011	Gelman and Sohn	Single stage penile island skin flap with dorsal BMG onlay	12	39	10 (83%)	NR
2012	Meeks et al.	(a) Meatotomy	(a) 73 meatotomy	61	(a) Meatotomy: 63 (87%)	Meatotomy: Stuttering intermittency, irregular stream, deviation of stream
		(b) Meatoplasty	(b) 20 meatoplasty		(b) Meatoplasty: 15 (75%) success	
2012	Onol et al.	Transurethral procedure with circular BMG	19	38	84.2% with durable outcome increased Q max	1 loss of graft
2014	Chowdhury et al.	Single stage ventral onlay with BMG	6	37	5 (83%)	None
2016	Nikolavsky et al.	Incisionless BMG ventral inlay	58	18	55 (95%)	None

NR not reported

8.3 Diagnosis and Treatment

Evaluation of fossa navicularis and distal urethral strictures begins with a thorough physical examination and careful inspection of the meatus. While more mild cases may be limited to the meatus, in the extreme cases the stricture can extend through the entire length of the urethra. Therefore, finding of a meatal narrowing on an exam alone is insufficient to accurately diagnose urethral strictures as it may grossly underestimate the severity and extent of the disease. In cases of even a minimally patent meatus, a retrograde urethrogram should be performed. If severe meatal stenosis is present, a lubricated 18–22 gauge plastic angiocatheter can be used to introduce contrast for a retrograde urethrogram. Alternatively, a previously established suprapubic tract would allow for an antegrade radiographic or/and endoscopic assessment of urethral patency. A voiding cystourethrogram (VCUG) or direct visualization with flexible cystoscopy should be considered in such occasions. Pre-operative assessment of stricture length is imperative in planning an optimal surgical approach. Underestimating the degree of involvement may lead to incomplete treatment of the stricture or potentially hasten future reconstructive efforts. Furthermore, inadequate preoperative preparation may actually lead to adverse surgical outcomes.

8.4 Treatment Overview

The focus of urethral stricture management should be twofold: sustainable urethral patency and acceptable penile cosmesis. The balance of these two functions makes management of distal urethral strictures complex. In addition, there are other goals: preserving sensory innervation of the glans, erectile function and avoiding a deviating urinary stream. The following section will highlight the different methods of stricture repairs as well as their limitations.

8.5 Urethral Dilation

Urethral dilation traditionally is regarded as the first-line therapy for distal urethral strictures. It is favored over upfront urethroplasties largely because of its being perceived as relatively minimally-invasive. Dilation can be performed by a variety of methods including balloons, filiform and followers, urethral sounds, and catheters. Although urethral dilation usually provides immediate functional results, there is a high recurrence rate especially in men with prior failed endoscopic procedures [6]. Veeratterapillay and Pickard have observed 85% recurrence of urethral stenosis at 2 years follow up after urethral dilation [7]. An attractive option in the short-term, urethral dilations require repeated interventions and are not serve as a permanent solution. Urethral dilation should be avoided in patients with lichen sclerosus as it may cause proximal progression of the stricture by creating an adverse inflammatory response in the proximal portion of the urethra [8]. Overall, routine repeated dilations as an option for chronic management of urethral strictures should be mainly considered in patients who are medically unfit to tolerate a more invasive procedure or wish to avoid perineal urethrostomy.

8.6 Direct Visual Internal Urethrotomy

Direct visual internal urethrotomy (DVIU) is another popular modality for an endoscopic management of urethral strictures. The modern form of this technique was first introduced by Sachse in 1974, and has been utilized in the in the management of all types of urethral strictures [9, 10]. In several retrospective studies, DVIU with either cold knife or laser, has failed to produce consistent outcomes with reported success rates ranging between 8% and 85%. Pansadoro et al., found that DVIU for distal urethra involvement was associated with a significantly lower success rates compared to more proximal segments such

as in the bulbar urethra (16% vs. 42%) [11]. Furthermore, Heyns and colleagues in their prospective study have shown that if the first urethrotomy fails within 3 months, the second urethrotomy would fail 100% of the time [12]. The lower success rates could be attributed to DVIU being technically more challenging in the distal segments of the urethra as this anatomic location does not provide adequate support with handling the scope or fulcrum for the cold knife.

Notwithstanding their popularity due to simplicity and reputation of being minimally-invasive, both urethral dilation and DVIU are associated with high recurrence rates thereby requiring repeated interventions. Additionally, Steenkamp et al. demonstrated in their prospective study involving 210 patients after dilation or urethrotomy that longer length of strictures inversely correlates with stricture recurrence rate after these procedures [13].

8.7 Meatotomy

Meatotomy and meatoplasty are the two open reconstructive procedures traditionally utilized to treat meatal stenosis and distal urethral strictures. Meatotomy is typically reserved for short distal strictures evolving meatus. Meatoplasty can be utilized if longer and more proximal segments of the FN are involved or in cases of previously failed meatotomy. Meeks et al. retrospectively studied 93 of patients undergoing meatotomy and meatoplasty procedures and found that that overall 84% of males after any of these procedures had successful outcomes without need for further intervention [14]. A difference in success rates between meatoplasty (75%) and meatotomy (87%) was observed. These differences are suspected to be a reflection of meatoplasty being performed for longer strictures, more extensive proximal FN involvement, or previously failed meatotomy.

An extended meatotomy (an extension of the meatal incision) has been proposed by Morey et al. as a salvage therapy for recurrent or complex strictures [15]. In a cohort of 16 patients treated by this approach, the authors report on

successful outcomes in 86% at 52 months of follow up. Historically, both meatotomy and meatoplasty involve splaying of the ventral glans as the first step of the repair. As a result, the most bothersome aftereffects of these procedures include urine spraying and stream deviation during voiding. Another concern with ventral incision meatotomy is the aesthetic outcome and resemblance of a hypospadiac glans. To counteract these untoward outcomes Malone et al. introduced a procedure that is performed through an inverted V relaxing incision at the meatus. In a study by Verdejo et al. a Malone-type meatoplasty was performed in 57 men who reported a significant improvement in post-operative peak flow of urine in addition to decreased post-void residual urine [16]. At a mean of 39.5 months follow up, 3.5% of patients (2/57) had meatal stenosis recurrence. Although this technique produced excellent outcomes with regards to urethral patency, it was only moderately successful to prevent urine stream deviation and spraying seen with the traditional meatotomy.

8.8 Urethroplasty Techniques

Numerous urethroplasty techniques have been proposed for the treatment of fossa navicularis or distal urethral strictures. Unlike the previously mentioned management options which were relatively non-invasive, most urethral reconstruction approaches require skin incision with either graft or flap use. More recently several transurethral or “incisionless” urethroplasty techniques have been described.

Distal anterior urethral stricture repair can be achieved with a tissue flap or a graft placement. Common tissue transfer techniques include fasciocutaneous flaps and oral mucosal grafts. Recently other tissue types for reconstruction have been described including rectal mucosa and autologous engineered buccal mucosa grafts [17, 18]. Although tissue flaps and grafts are described to have the compatible success rates in distal urethral reconstruction, certain local flaps have been associated to have a higher morbidity [19]. Aside from donor site morbidity, major

complications of urethroplasty include glans dehiscence and fistula formation in incision-dependent approaches.

8.9 Fasciocutaneous Flaps

Fasciocutaneous penile skin flaps for fossa navicularis reconstruction were first discussed by Cohney et al. in 1963 as a salvage option for a stenosed meatotomy [20]. The authors have pioneering a method involving a transverse preputial or penile skin flap which was harvested and then rotated on a dartos pedicle to be folded inward to reconstruct the ventral portion of the urethra. The purpose of the dartos pedicle was twofold: (1) to recreate the ventral aspect of the urethral lumen and (2) to fill the glans defect. This method produced satisfactory functional outcomes as reported by the authors. However, due to the twisting of the dartos pedicle the glans appeared rotated. To address this glans distortion Blandy et al. proposed advancing a U-shaped penile skin island into the defect [21]. This method was successful in correcting the twisting, however, stream splaying secondary to a ventral urethrotomy was found to be an issue.

Brannen et al. further modified this technique to address the shortcomings of the earlier variations

[22]. Brannen's technique involved an inverted midline penile skin island which was interposed into the meatotomy defect. With an epithelial strip of both the glans and the penile skin, Brannen was able to advance the folded skin further and suture the penile skin to the glans in a face-to-face manner thereby eliminating hypospadias and allowing for urine stream control. De Sy proposed a technique similar to the flap advancement seen with Brannen's method. This modified method added an additional step involving closure of the ventral glans to produce a more cosmetically appealing penis [23].

In 1987 Jordan described a ventral transverse preputial island flap technique that helped further change the management of FN and distal urethral strictures [24]. First, an external urethrotomy was performed to excise the diseased segment of urethral tissue, and glanular flaps were created by raising the glans off the underlying corpora (Fig. 8.1). The preputial island flap was inverted so that the epithelium faced the lumen and then transposed to fit over the urethrotomy defect. The glanular flaps were then used for tension-free ventral closure over the reconstructed fossa navicularis.

In a follow up study Virasoro et al. have evaluated the efficacy of Jordan's technique and found that at an average follow up of 30 months, 96%

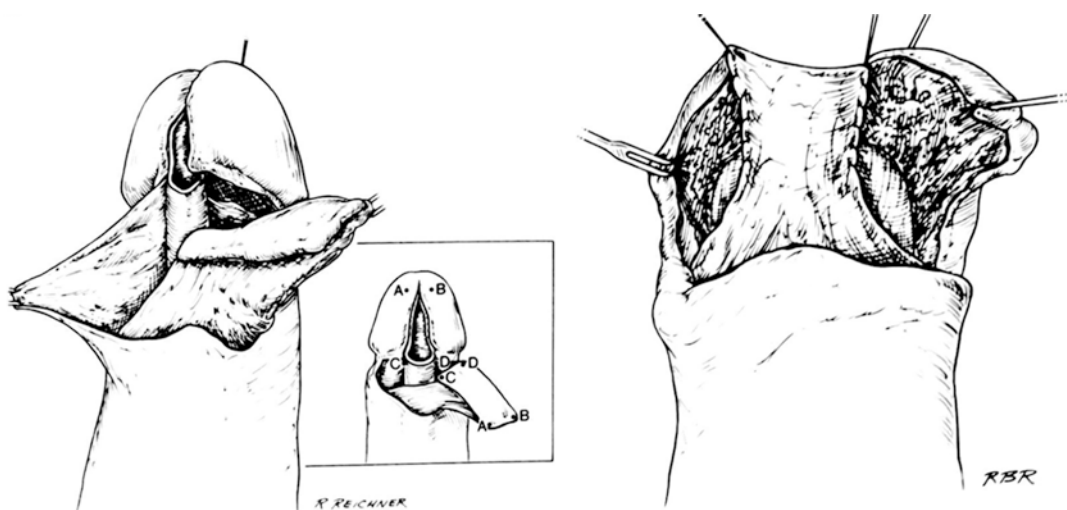


Fig. 8.1 Depiction of ventral transverse prepuccial island flap urethroplasty. An external urethrotomy is conducted followed by creation of glans wings. (Figure reprinted with permission from BJU International, John Wiley and Sons)

(24 out of 25) of patients were stricture free, and only 12% (3 out of 25) complained of urine spraying [24, 25]. Jordan's method as described was shown to produce long-term favorable results. Virasoro et al. then reported on the same method as Jordan and included 35 patients with an average of 10.2 years follow up, and showed an 83% success rate. Of note, the patients without the diagnosis of lichen sclerosus had excellent outcomes. However, in patients with history of lichen sclerosus this technique was successful in 50%. These findings were corroborated by Venn and Mundy et al who found 100% recurrence in patients with lichen sclerosus who were treated with genital skin flaps [26, 27]. These findings underlined the importance of avoiding the use of genital skin for fasciocutaneous flaps in those with lichen sclerosus.

To evaluate cosmetic outcomes of Jordan's technique Holland et al. applied the hypospadias objective score evaluation (HOSE), an

objective scoring measure of hypospadias repair [28]. The authors found that at 3 months follow up, majority of the patients had desirable outcomes with all patients reporting the meatus at the tip of the glans (HOSE score 4/4), 84% demonstrating a ventral slit meatus (HOSE score 2/2), 88% voiding with a single stream (HOSE score 2/2), 100% with straight erections (HOSE score 4/4), and 100% without formation of fistulas (HOSE score 4/4).

To address the potential complication of glans dehiscence Armenakas et al. proposed an alternative method utilizing a 'glans cap' (Fig. 8.2) [29, 30]. The 'glans cap' method differed from the 'glans wings' method seen in Jordan's technique, in that the glans was not incised ventrally. Instead, the glans was raised intact off both corpora with subsequent tunneling of the neourethral segment under the glans. The authors showed durable functional outcomes with 95% success (18 out of 19) at a mean follow up of 43 months.

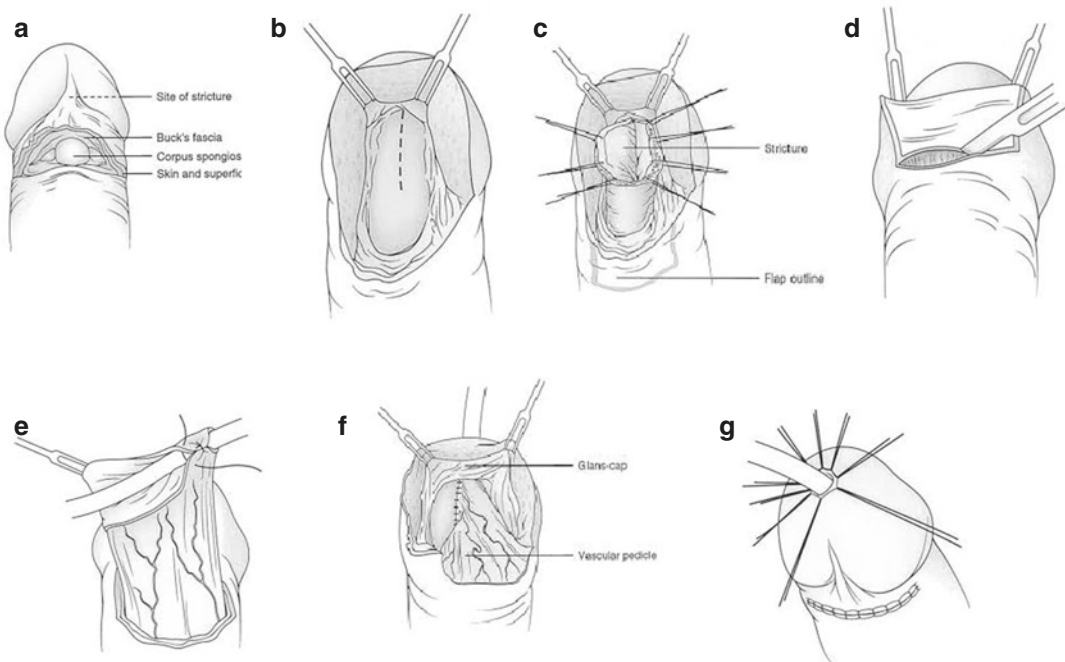


Fig. 8.2 Illustration of step-by-step glans cap procedure as described by Armenakas and McAninch. (a) A ventral sub-coronal incision for urethral exposure. (b) Creation of glans wings. (c) Longitudinal stricturotomy. (d) Fasciocutaneous ventral transverse island flap creation.

(e) Flap mobilization with fascial pedicle preservation. (f) Urethral substitution. (g) Glans-cap creation with patent neomeatus. (Figure reprinted with permission from Urologic Clinics of North America, Elsevier)

8.10 Buccal Mucosa Grafts (BMG)

Lichen sclerosus poses a significant barrier to the use of genital skin flaps in urethroplasty as previously described in treatment of urethral stricture disease. The relationship between lichen sclerosus and stricture recurrence was clearly outlined by the findings made by Venn and Mundy. Their study compared the outcomes between a single-stage pedicled penile skin flaps and a two-stage free graft urethroplasty in patients with lichen sclerosus [26, 27]. Their study included 28 patients and found that among the 12 patients who underwent pedicle skin flap, there was a 100% (12 of 12) recurrence at a mean follow up of 5 years all of whom warranted further surgical intervention. In contrast, among patients who had a posterior auricular skin or buccal mucosa graft the authors found only 8.3% recurrence (1 of 12) at a mean follow up of

3 years. Specifically, there were no recurrences seen in those treated with buccal mucosa grafts at a mean follow up of 3 years. These findings then led Venn and Mundy to conclude that genital skin that is afflicted by lichen sclerosus should not be used for urethral repair.

To avoid reliance solely on genital skin for distal urethral reconstruction Gelman and Sohn have developed a hybrid of Jordan's fasciocutaneous flap combined with buccal mucosa graft (Fig. 8.3) [31]. Their method utilized a buccal mucosa graft to create the dorsal urethral plate and Jordan's pedicled skin flap to construct the ventral plate. Twelve patients underwent this type of urethroplasty, and at a mean follow up of 39 months all 12 were found to be free of recurrence. The authors did report on two cases of urethrocutaneous fistulas associated with this technique.

In an effort to completely avoid any use of skin in urethral reconstruction, Goel et al.

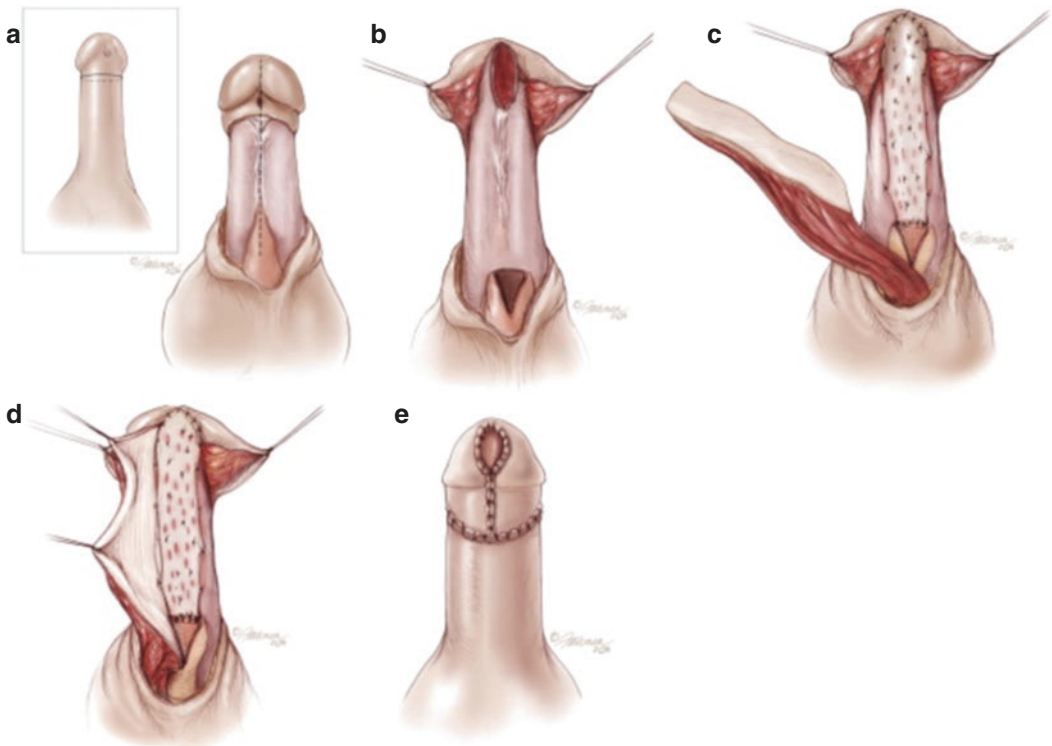


Fig. 8.3 Illustration of single stage penile island skin flap with dorsal BMG onlay. (a) Degloving of the penis. (b) Spatulation of the proximal urethra. (c) Quilting of a buccal mucosal graft to the ventral penile surface. (d) Urethral

tubularization using penile skin flap. (e) Glanular urethral meatus closure. (Figure reprinted with permission from The Journal of Urology)

proposed a double buccal mucosa graft technique for the management of fossa navicularis strictures [32]. This technique required a ventral incision through the glans followed by one graft being placed as dorsal inlay and the other as a ventral onlay. Surprisingly, this method required daily postoperative urethral calibration by patients for 1 month. The authors reported on 10 patients who at an average of 13.5 months (range 5–36 months) had no stricture recurrences. Urine splaying was the only functional challenge that was encountered.

A simplified procedure involving only a ventral buccal mucosa graft onlay was described by Chowdhury et al. [3]. The proposed approach involved ventral urethrotomy and spatulation of urethra to create a dorsal native urethral strip, ventral stricture excision and ventral buccal mucosal graft placement covered with lateral vascular tissue which was rotated ventrally. This series included six patients, of which five (83.3%) demonstrated favorable functional and cosmetic outcomes at an average of 37-month follow up.

8.11 Transurethral Urethroplasty

The concept of transurethral urethroplasty offers an advantage over other open techniques which rely on skin incisions and glans spatulation. The open techniques are inherently predisposed to and known for cosmetic and functional complications including wound complications, fistula and glans dehiscence. In contrast the transurethral techniques carry a premise of avoidance of any external incision and subsequent wound complications.

Onol et al. described a transurethral approach to distal urethral stricture resection followed by circumferential proximal and distal buccal mucosa graft anastomosis [33, 34]. This technique was used in 19 patients with fossa navicularis strictures, of whom 16 were affected by lichen sclerosus. The authors described technical challenges with a purely transurethral approach in some patients and resorted to a ventral sub-coronal counter incision in nine patients to allow for better scar excision and proximal graft

anastomosis. At a mean follow up of 38-months, 16 of the 19 patients (84%) reported successful functional outcomes, while two patients developed strictures at the proximal anastomosis edge, and one patient developed a graft loss.

The first truly transurethral urethroplasty avoiding any external skin incision was described by Nikolavsky et al. in 2016 [35]. This method was a modification of Naude's endoscopic bulbar urethroplasty, which involved a transurethral stricture excision followed by transurethral delivery and fixation of a buccal mucosa graft (Fig. 8.4) [36]. This incisionless approach avoided potential urethrocuteaneous fistula formation, glans dehiscence and undesirable cosmetic outcomes. Following the initial case series, a multi-institutional study was conducted which included 58 men who underwent this procedure. Forty-three of these men had at least 12 months follow up and 40 of the 43 patients (93%) demonstrated no stricture recurrence. None of the 58

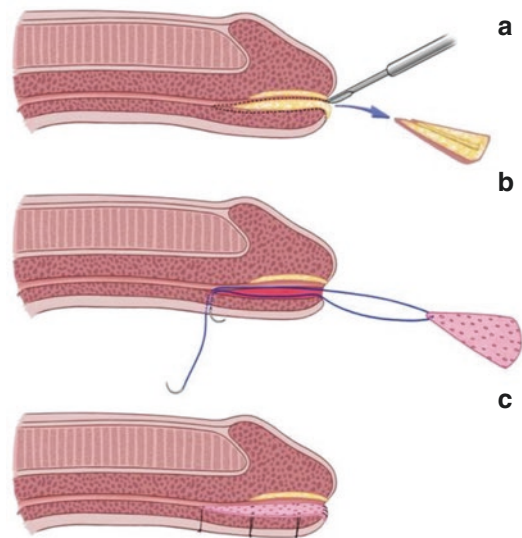


Fig. 8.4 Illustration of transurethral ventral buccal mucosal graft inlay urethroplasty. (a) Shallow ventral wedge resection performed transurethrally. (b) Placement of absorbable stitch through the apex of the graft and proximal apex of the urethrotomy. (c) Transurethral delivery and fixation of the graft with double-armed sutures placed inside-out and distal fixation of the graft to create a patent meatus. (Figure reprinted with permission from International Urology and Nephrology, Springer)

patients had fistula formation, glans dehiscence or adverse cosmetic outcomes [37].

8.12 Conclusion

In this chapter we outline the management strategies and repair techniques of FN and distal urethral strictures along with individual advantages and pitfalls. Although there is currently no gold standard for distal urethral stricture disease, there are feasible reconstructive treatment options with successful functional and esthetic outcomes. The main challenges associated with FN and distal stricture repairs include preservation of cosmesis and functionality, and achieving long-lasting urethral patency. Patient-specific factors should be taken into account when deciding the optimal approach in treating these strictures. Long-term follow up with uroflow and post void residual evaluation along with flexible cystoscopy and assessment of patient-reported outcomes are strongly recommended.

Key Summary Points

- Contemporary series have shown a shift in inflammatory causes of distal urethral strictures to lichen sclerosus and iatrogenic causes
- It is beneficial for longterm functionality to avoid reconstruction with local skin due to lichen sclerosus
- The goal of distal urethral stricture repair should include preservation of the glans with feasible functional and aesthetic outcomes

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Complex Hypospadias in Adults: Primary Repair and RE-DO Surgery

9

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9.1 Introduction

Urogenital tract is one of the systems most frequently affected by congenital abnormalities, either as isolated or associated birth defects. As it is well known, hypospadias represents one of the most common urogenital congenital anomalies that affects 1 in every 200–300 male livebirths. The severity of hypospadias is usually determined by the position of the meatus. However, hypospadias complexity is nowadays assessed using detailed criteria regarding the division of the corpus spongiosum, together with the presence of other hypospadiac anatomical features [1]. From the time it was first mentioned in medical literature, hypospadias treatment has developed more than 300 different surgical techniques, which proves that hypospadias management still poses a great challenge for pediatric surgeons and pediatric urologists [2]. One thing is certain, the objective of each of these surgical techniques and their modifications is to perform urethral reconstruction, to correct penile curvature, if present, to complete glansplasty and penile skin recon-

struction, with the aim of creating a functional and esthetically acceptable penis in a single stage surgery.

The recommendation from the Section of Urology of the American Academy of Pediatrics suggests that the best time to treat hypospadias is by the age of 18 months, when the child still has no genital awareness, and when the fear of parental separation will be forgotten [3]. Primary repair in adults is usually rare, and the majority of studies published on this so far, have reported higher complication rates and dissatisfaction, combined with demureness and lack of self-confidence.

As the penis grows in puberty, some patients, who had previously had successful primary hypospadias repair, can complain of newly developed problems regarding penile functionality or appearance. In communities where circumcision is not common, even a circumcised penis can lead to a certain lack of self-esteem.

Adults with hypospadias who were not surgically treated for their anomaly in childhood form a special group, seeking to obtain functional and esthetically satisfying genitals. Failed hypospadias in adults is often associated with persistent urethral problems, such as urethral stricture and/or urethrocutaneous fistula, as two most common postoperative complications, micturition problems, lower urinary tract symptoms, ventral curvature, chronic urinary tract infections, persisting hypospadias, ejaculation problems, infertility,

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dissatisfaction regarding genital appearance and sometimes psychosexual dysfunction [4].

Transitional urology or urological congenitalism is a term that was introduced in 2015 by American Urological Association (AUA) to cover the management of patients with severe congenital urological anomalies originally treated in childhood, later in adulthood. This group of renowned experts formulated recommendations related to the management of congenital anomalies of genitalia as well as treatment of patients with complex urological diseases. Transitional urology aims to transfer these patients stress-free from a pediatric to an adult reconstructive urologist [5, 6].

9.2 Primary Hypospadias Repair in Adults

Majority of papers regarding hypospadias repair mainly deal with pediatric population. Primary repair in adult patients is not that common, especially because the neonatologists, pediatricians and general practitioners are educated to recognize the genital deformities that need to be evaluated and treated by pediatric surgeons and urologists, so the majority of patients get the treatment for their hypospadias in childhood. Nevertheless, there are adult patients who have never been surgically treated that come for primary hypospadias repair. Although hypospadias repair in adults in most cases includes the same surgical approach, there are, however, quite important differences such as nocturnal and diurnal erections, intraurethral secretions and wound healing. In adults, penile size in erection may differ from the flaccid state up to 4:1, which can compromise the healing process and lead to postoperative complications. This is one of the reasons to recommend that adult hypospadias repair always be performed in erection, so that grafts and flaps necessary for the reconstruction can be adequately estimated [7].

There are significant structural changes in the healing process with aging. Greater production of pro-inflammatory cytokines expressed by fibroblasts derived from the foreskin is observed in adolescents and adults when compared to children, which, in turn, can explain the higher complication rate in hypospadias repair in older

patients. Concerning the age-related changes and differences in extracellular matrix (ECM) of the human urethral plate in patients treated for hypospadias, da Silva et al. concluded that adult urethral plate ECM was characterized by an abundant collagen content (type I and III), low cellular density, scarce elastin fibers and no vascular sinuoids. According to the authors, these findings may play an important role in neourethral healing in adult patients treated for hypospadias and lead to a higher complication rate [8]. In addition, in adult males, the dartos fascia is less developed, skin elasticity is lower and the dorsal penile hood is smaller. The impact of hair-bearing skin is also important, as is the possible presence of human papilloma virus warts or other skin changes which can limit tissue availability in hypospadias repair in adults. As previously mentioned, the presence of nocturnal and diurnal erections must be kept in mind in order to choose the adequate surgical approach that will diminish the possibility of complications.

The goal of primary repair in adults is the same as in children: to correct the present penile curvature, to reconstruct the urethra with an orthotopic meatus and to create an esthetically acceptable penis. Surgical approach in adults is the same as in pediatric hypospadias repair: the choice is made on a case to case basis and depending on the surgeon's familiarity with the technique. After skin degloving and chordectomy, intraoperative verification of curvature is mandatory, as is its correction prior to urethroplasty. The presence of the curvature is checked intraoperatively, either with artificial or pharmacological erection with prostaglandin E1 (PGE1) [7]. For curvature correction, plication technique with the use of absorbable monofilament 2.0 suture (polyglecaprone 25) could be a method of choice, without the danger of extreme penile shortening. When distal forms of hypospadias are present, with sufficiently wide and developed urethral plate, a high success rate is achieved using tubularized incised urethroplasty (TIPU) in combination with dartos flap to prevent postoperative fistula formation as a one-stage procedure. Mobilization of the dartos flap is possible due to the axial course of the blood vessels, which allows the creation of a wide hole at the base of

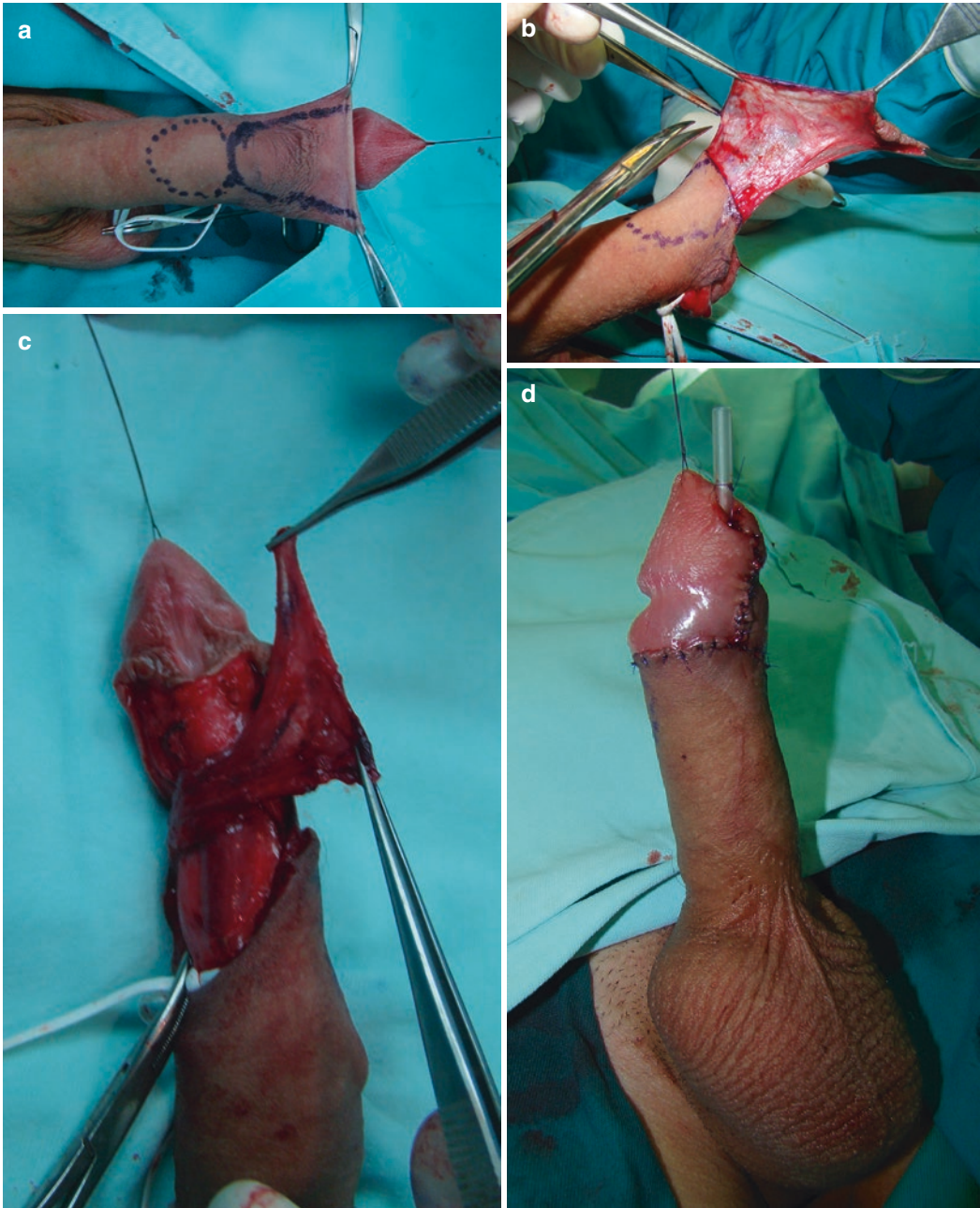


Fig. 9.1 TIPU for distal primary hypospadias repair in adults. (a) Marked lines show the size of the dorsal dartos flap and dotted circle shows the size of the flap's base. (b) De-epithelialization of the flap is performed from the proximal to the distal direction. (c) Flap is transposed with

a button-hole maneuver to the ventral side. There is no pressure on the ventral penile structures and penile body. (d) Outcome at the end of surgery. Glansplasty and penile skin reconstruction with an orthotopic meatus

the flap according to the penile and glans size, without the possibility of damaging the blood supply, therefore limiting the use of this flap to midshaft and proximal hypospadias. Urethra

should be tubularized with the running absorbable monofilament 5.0 suture (poliglecaprone 25) over a silicone stent not less than 12 Ch [9–11] (Fig. 9.1a–d).

In severe hypospadias, preoperative planning is essential because of severe ventral curvature, short, usually undeveloped urethral plate and tissue deficiency for both urethroplasty and penile shaft reconstruction. In most centers, two-stage surgery would be the method of choice for severe hypospadias repair, with different tissues for urethral replacement. First stage would include penile straightening with the removal of all fibrous tissue and first stage of urethroplasty with the use of free tissue graft (usually oral mucosa graft) creating the urethral plate, and its tubularization 6 months later. Possibility of graft shrinkage during the period of maturation must be taken into consideration prior to graft harvesting. There are several different approaches in penile straightening. The most commonly used is the dissection of the short dysplastic urethral plate with subsequent dorsal plication of tunica albuginea. This technique has its drawbacks, such as penile shortening in already affected penile length in proximal hypospadias. Other procedures that tend to keep the penile length are based on dissection and division of the urethral plate, with grafting of the opened tunica albuginea with different materials. The limiting factor of this approach is unfeasibility of urethral reconstruction in the same stage [12].

In cases where the skin availability and quality allows one-stage repair, the use of oral mucosa graft in combination with longitudinal dorsal skin flap transposed ventrally to create the adequate tension-free urethral tube over the silicone urethral stent 14 Ch, can be applied with a satisfying outcome. Buccal mucosa graft required for the urethroplasty is usually harvested from the inner cheek, like previously described and quilted with interrupted absorbable monofilament 5.0 suture (poliglecaprone 25) to the cavernosal bodies to prevent formation of a hematoma which could compromise graft survival and consequently lead to complications. In severe hypospadias repair, the urethral defect can exceed the size for simple tubularization with two-stage buccal mucosa grafts, and therefore the use of a combination of a smaller buccal mucosa graft

and a vascularized skin flap provides a better chance for a successful outcome as a one-stage repair. Postoperative use of a vacuum device is advised for 3–6 months to prevent shrinkage of the buccal mucosa graft and possible recurvation [12, 13].

One of the largest series of adult hypospadias repair is the study of Li et al. where 113 patients with hypospadias were treated using a bladder mucosa graft with the success rate of 87.6% [14]. However, because of the invasive and time-consuming harvesting of the graft with a high possibility of mucosa perforation during dissection, and relatively high meatal stenosis rate, this technique that was popular in the nineteen-nineties is no longer frequently used [15].

A greater failure rate is seen in re-do cases in adult population than primary hypospadias repair, ranging from about 10–37.5%, with the complication rate doubling. Severe hypospadias cases bring even higher failure rate when compared with distal forms [16].

Because of the above, primary repair is advocated in childhood so the functional, cosmetic and psychosexual problems could be avoided.

9.3 RE-DO Hypospadias Repair

Success rate in hypospadias repair varies from study to study and depends on the type of hypospadias. Severe hypospadias are associated with a higher percentage of postoperative complications. The largest number of studies published so far deal with short-term follow-up of patients treated for congenital urogenital anomalies with a 5–58% complication rate, depending on the type of hypospadias and surgical technique used [2, 17, 18]. It is somewhat predictable, as the majority of patients are lost in follow-up, for different reasons, so the conclusions in these studies are made only based on the reviewed subjects. It could be assumed that the hypospadias treatment success rate could be lower, if all patients were included into the

present studies. Accordingly, one of the first largest series that dealt with adult patients after hypospadias treatment included 213 young men out of whom 44% requested further surgical treatment to improve the function and appearance of their genitals [19].

All surgical complications presenting in adult patients are divided in two major groups: urethral and non-urethral complications after hypospadias repair. In addition to showing primary hypospadias repair in adults, the aim of this chapter is to present the up-to-date approaches of RE-DO hypospadias repair and review of hypospadias cripple treatment as a particular and most demanding type of failed hypospadias repair.

9.4 Urethral Complications

As mentioned, the most common postoperative complications after hypospadias repair are related to urethroplasty and usually present either as urethral stricture or as urethrocutaneous fistula. Aldamanhori and Chapple speculated that late urethral complications can develop because the man-made urethra does not follow the growth of other genital tissues during puberty. Also, poorly developed or missing spongiosum in hypospadias could prove insufficient for vascular support of the neourethra, resulting in higher susceptibility to trauma in erection. Finally, hypospadias repair requires good experience and knowledge not only in urology, but in reconstructive surgery as well [20]. Familiarity with at least two different surgical techniques for the given type of hypospadias increases the chance for subsequent postoperative success.

The most common surgical technique for primary distal hypospadias repair is the tubularized incised plate urethroplasty (TIPU), published in 1994 by Snodgrass, with a complication rate of 14%. It was based on the fact that there was no proper coverage of the new urethra, so further modifications of the original technique led to a reduction of postoperative fistula [10, 11].

However, in long-term follow-up, during adulthood, the real rate of complications after primary repair in childhood is about 30%. This suggests that complication-free techniques for hypospadias are not yet available [20].

9.5 Urethral Fistula

Urethrocutaneous fistula is the most common complication after hypospadias repair. Differences in wound healing and tissue quality, possible genital hair, nocturnal erection, existing urethral secretions and concomitant comorbidities make it more frequent in adults than in children [21]. Fistula is usually reported by the patient himself through the information about the quality of the urinary stream during voiding. Correction of fistulas always depends on their location, size and number, and the decision on the most appropriate approach is usually made during surgery. Preoperative urethrocystoscopy is advised to exclude additional deformities or foreign bodies (ex. stone) or hair in urethral lumen that can compromise planned fistula repair.

Surgical principle of fistula closure includes dissection and excision of the whole channel between the skin and urethra and closure of the urethral defect with absorbable suture material. Good vascularized subcutaneous tissue is recommended for additional covering of the sutured urethra.

In cases where the penile urethra is positioned superficially and without supportive tissue, dissection of the fistula and covering of the defect could be more difficult. It is preferable to perform complete urethroplasty and to provide support for the reconstructed urethra (Fig. 9.2a–c). Sometimes small subcoronal or glandular urethrocutaneous fistula may require a more extensive dissection, due to a lack of surrounding healthy tissue [22]. Urethral stent is very useful for urethral cleaning and drainage of the secretions during the healing process. Also, using of suprapubic tube is recommended for easier urine passage.

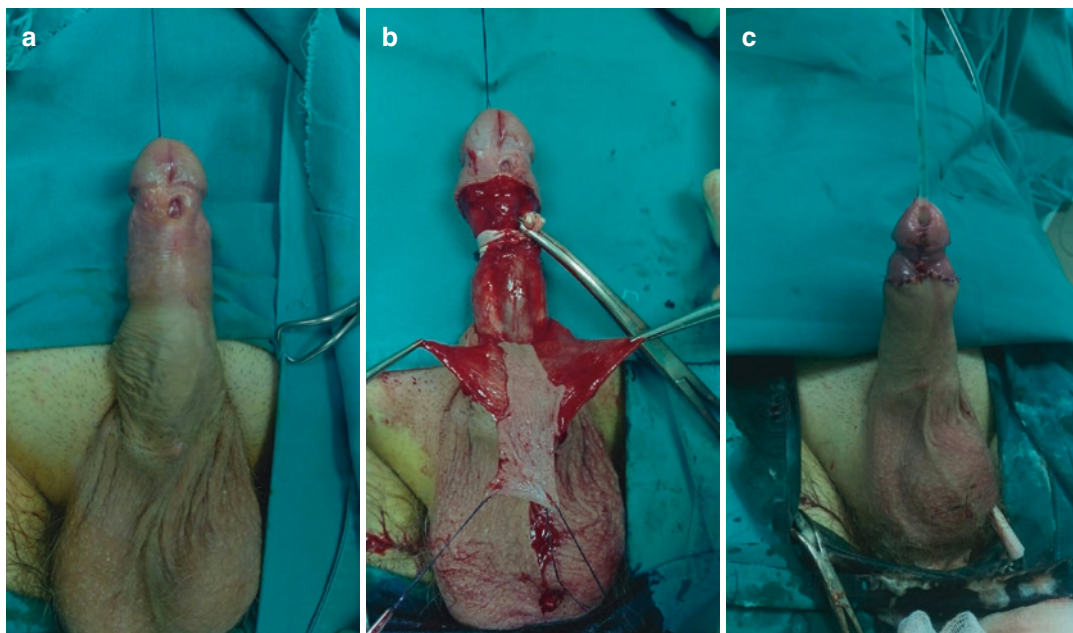


Fig. 9.2 RE-DO urethral fistula repair. (a) Large urethrocutaneous fistula with superficial urethra. (b) Dorsal longitudinal island skin flap was mobilized and transposed

ventrally for urethral reconstruction. (c) Final aspect with the penile skin reconstruction

9.6 Urethral Stricture

The rate of urethral stricture occurrence in adults is not established and varies from study to study with the different time of onset after primary repair [4, 23]. Urethral stricture can involve the new meatus, junction of the native and reconstructed urethra, or the entire neourethra [24].

Meatal stenosis occurs usually within a short period of time as the result of inadequate size of the glans during hypospadias repair, or it can happen later, several months or years after the initially successful urethroplasty. Special type of meatal stenosis is the consequence of lichen sclerosis (LS), presenting in patients previously treated from hypospadias. In patients with difficulties in voiding, urethrography, urethroscopy and uroflowmetry are mandatory for proper stricture diagnosis.

Urethral stricture treatment depends on many factors: patient age, localization, length, comorbidities, quality and availability of genital skin or other tissues that can be considered for urethral stricture repair.

Meatal stenosis is usually repaired in a single stage dorsal or ventral meatoplasty in Heineke-Mikulicz fashion using absorbable sutures. Simple dilation of the stenotic meatus is no longer proposed, as it won't give satisfying result in the long run. In cases with smaller volume of the glans, buccal mucosa graft is recommended for the augmentation of glanular urethra [25].

When treating penile urethral stricture in failed hypospadias repair we should bear in mind the availability, elasticity and vascularization of the surrounding tissues [26]. In patients with multiple failed stricture repairs, scar tissue must be completely removed, and reconstruction should commence from the healthy margins. Reconstructed part must not be narrower than the rest of the healthy urethra. In some occasions, we might decide to perform a two-stage procedure instead of a one-stage. The final decision of the surgical technique for stricture repair in majority of cases will be made intraoperatively, based on the surgeon's evaluation of the urethra under direct vision [27].

Looking into embryology and anatomy of the hypospadiac penis, distally from the divergence of the corpus spongiosum, the vascularization of the urethra and urethral plate is questionable, but proximally all of the structures on the ventral side of the penis are normal [28]. This information can help us in making decisions regarding stricture repair. For confirmed penile urethra strictures, Craig et al. proposed single-stage urethroplasty – EPA (excision and primary anastomosis) in patients with short urethral strictures and those in which the stricture is located outside the prior hypospadias repair; however, they also proposed “to restrict the distal mobilization of the urethra in order to preserve perforating blood vessels that vascularize the bulbar urethra separate from the more distal blood supply arising from the penile arteries”. According to the authors, graft urethroplasty would be a much safer procedure [29].

Augmentation urethroplasty is proposed for the treatment of strictures greater than 2 cm, using either skin flap or tissue grafts. The skin flaps are usually limited due to skin availability and quality, as well as the urethral stricture location. Tissue grafts are more commonly used, as they are usually easier to harvest and transfer to the recipient site. Since a tissue graft does not contain its own blood supply, it survives through the imbibition of nutrients during the first 48–72 hours. Different types of tissues were used as free grafts for stricture repair throughout history (split-thickness skin, full-thickness skin, bladder mucosa, colonic mucosa, oral mucosa) and some were shown to be superior than others. An ideal tissue graft should contain the following characteristics: easy harvesting, hairless, resilient, viable in wet environment and with a structure that allows for neovascularization. According to these characteristics for the ideal graft in urethroplasty, it seems that oral mucosa comprises a majority of the required features: it is easy to harvest with minimal morbidity, it is hairless, resilient, with a thick epithelium and thin lamina propria which makes it less prone to shrinkage and more receptive to neovascularization [30].

As mentioned before, vascularization to the corpus spongiosum is compromised in hypospadias, especially in severe forms and after multiple

failed repairs. In these cases, stricture repair must be performed with caution to avoid extensive mobilization of the urethra that can jeopardize the blood supply and lead to ischemic changes. Augmentation urethroplasty is used in penile and bulbar stricture repair with 88–90% success rate in the reviewed studies [30, 31].

The one-stage onlay dorsal graft urethroplasty includes penile degloving and mobilization of the strictured urethra with longitudinal midline dorsal incision, with the patch (oral mucosa, preputial skin, penile hairless skin) quilted to the corpora cavernosa, creating the dorsal urethral wall [30, 32, 33]. Many would agree that mobilization of the penile urethra would be too great a challenge after failed hypospadias repair for dorsal graft placement, and would therefore not recommend a one-stage repair in such cases [29, 34].

Ventral placement of the graft showed good results in bulbar urethral strictures as corpus spongiosum is thicker than in penile urethra and urethra mobilization is avoided [34, 35]. Even though many authors believe that corpus spongiosum is not thick enough in hypospadiac patients, our modification of ventral placement of the buccal mucosa graft anchored with “U sutures” resulted in the prevention of graft shrinkage, movement and haematoma formation between the graft and periurethral tissue that provided for better healing in our series of patients with urethral stricture after hypospadias repair [36].

A special problem occurs in cases with a completely obliterated urethra, with no viable urethral mucosa. The affected and strictured part of the urethra must be completely excised, and direct end-to-end anastomosis is the best solution for short bulbar urethral strictures. End-to-end anastomotic urethroplasties are not advised for penile urethra stricture repair as they may lead to penile recurvation or shortening, with a higher rate of failure [37]. Longer obliterate strictures, especially those located in the penile urethra, require staged repair as described by Johanson [38, 39]. Sometimes, a temporary proximal urethrostomy performed by spatulating the native healthy urethra and suturing it with interrupted monofilament sutures to the surrounding skin could be useful in cases of pan-urethral strictures

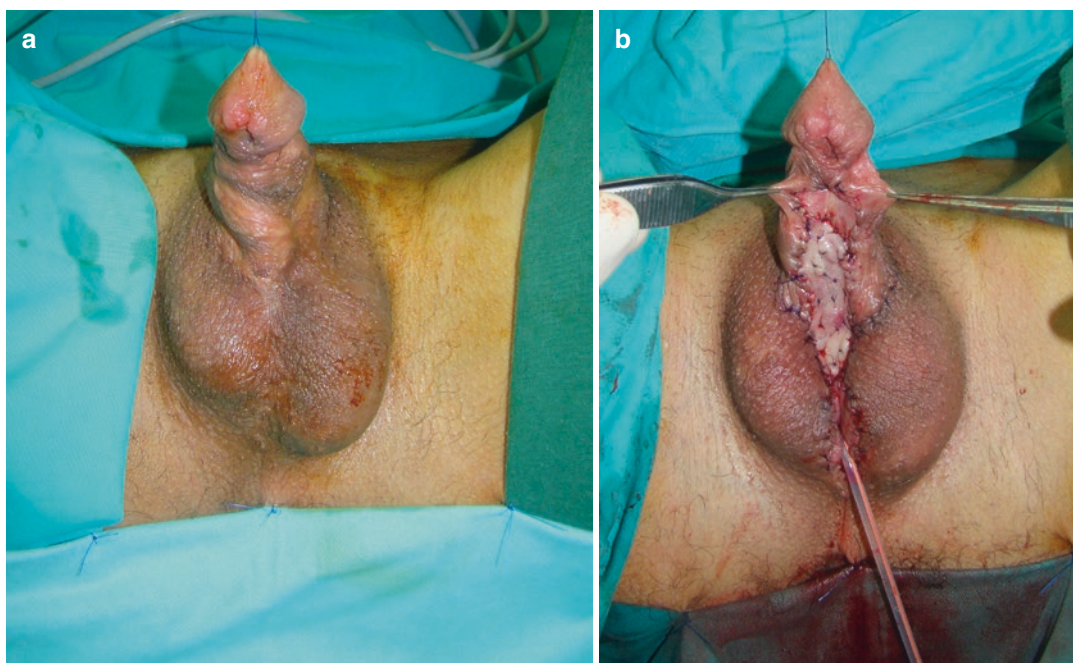


Fig. 9.3 Obliterative stricture after failed hypospadias. Staged repair. (a) Preoperative appearance. Scarred ventral aspect of the penis. (b) Buccal mucosa graft is

positioned ventrally and quilted to the corpora cavernosa. Proximal urethrostomy is created at the same stage

or in lichen sclerosis. Further urethroplasty is performed by complete excision of the obliterated urethra until the healthy part is reached; usually, oral mucosa grafts are placed and quilted with interrupted monofilament 5.0 sutures (poligle-caprone 25) for better survival of the graft. The second stage is usually performed 6 months after the first stage, creating a urethral tube over the silicone catheter [25, 40] (Fig. 9.3a, b). Dual catheter placement is preferable, one suprapubic and one through the urethra. Compressive dressing (Coban, 3 M, Inc., USA) is applied for the whole postoperative period.

9.7 Urethral Diverticulum

Urethral diverticulum is a rarely described complication, usually related to a distal stenosis, meatal or penile. Typically, patients describe a sac along the path of the newly constructed urethra, collecting fluids that can be squeezed every time after voiding to prevent dribbling. Rarely, a diverticulum presents as a strong obstruction of

the urethra. A voiding cystourethrogram (VCUG) and uroflowmetry can be of help in preoperative diagnosis and surgical planning.

Treatment of urethral diverticulum involves an opening, usually in the midline, followed by urethroplasty using a monofilament running suture around the urethral stent of an adequate size for the patients' age. De-epithelialization of urethral tissue is recommended, providing good periurethral vascularized material to cover the suture lines and preventing a postoperative fistula. Placement of the suprapubic urinary catheter is advised for urine diversion and for better healing of the urethra. Plication of the urethral diverticulum is no longer advocated, although this type of the treatment has been reported as well [40].

9.8 Non-urethral Complications

Even though less common, non-urethral complications present an important percentage of complications which appear after hypospadias repair in childhood. They can be isolated or associated

with urethral complications, which makes the repair even more challenging, even for an experienced hypospadiologist. The most common non-urethral complications are glans deformity, residual curvature and trapped penis due to skin insufficiency.

9.9 Glans Deformity

One of hypospadias features is a cleft and flattened glans, somewhat shorter than average, sometimes with a ventral tilt. The majority of postoperative glans deformities are related to glans dehiscence during postoperative recovery, which results in irregular shape and scarring of the glans during pubertal growth.

The goal of the repair surgery is to reconstruct the glans to obtain a conical shape, minimizing the scar formation. A radical surgery with urethral mobilization and glans wings mobilization, in cases where the glans is developed and wide enough for these procedures will result in successful functional and esthetic repair. In cases of poorly developed glans and narrow urethra, where tension can be expected and there is a chance for the same – or new – postoperative complications, ventral skin flap or buccal mucosa graft can be used for urethra and glans augmentation [25, 41]. Fistula formation can be prevented using some available surrounding flaps (dartos, tunica vaginalis flap, etc.).

Glans hypoplasia is a common finding in patients with hypospadias in comparison to males without genital abnormalities. Sometimes, it is difficult or even impossible to incorporate the neourethra into the small glans without compromising the vascularity and survival of the urethra and the glans itself. For these patients, one solution is glans augmentation using a longitudinal double-faced flap. The flap is mobilized as an island skin flap from the outer and inner side of the prepuce and transposed ventrally with a “button-hole” maneuver to create the glanular part of the neourethra and to augment the glans. All suture lines are covered with vascularized subcutaneous tissue to prevent fistula formation [41, 42]. Another alternative for glans sculpturing

when urethra is functional and patent is the use of injectable materials such as hyaluronic acid gel used in plastic and reconstructive surgery [43].

9.10 Residual Curvature

One of the main steps in hypospadias repair is checking for the associated penile curvature. If present, curvature repair is performed before urethral reconstruction. Residual curvature after hypospadias repaired in childhood is not that common. Possible reasons for its appearance in adults could be: 1. Failure to identify and repair the curvature during the primary hypospadias surgery; 2. Inadequate correction of the penile curvature during the primary hypospadias repair; 3. “De novo” curvature that appears because of tunica albuginea irregularities during penile growth in puberty.

The most common cause of penile curvature in adulthood is failure to isolate the curvature during the surgery in childhood. The fact is that penile curvature is associated with severe forms of hypospadias, and thus the majority of surgeons do not check for penile curvature in distal hypospadias. However, almost 30% of milder forms of hypospadias are shown to be associated with significant ventral curvature that requires surgical correction [44]. Residual curvature usually appears at the time of penile growth and becomes visible enough for the patient to notice and complain about during sexual activity. Sometimes, the curvature aggravates during intensive sexual activity because of repeated minor trauma and a lack of spongy tissue. Residual curvature repair might be more demanding than the primary repair, because of possible scarring between the skin, neurovascular bundle and corpora cavernosa. The dissection must be precise and complete, so the complete straightening of the penis is obtained after curvature correction.

Presence of the curvature is detected intraoperatively with the artificial erection test using saline injection or pharmacological erection using prostaglandin E1 after complete degloving and removal of the fibrous chordee [7]. Correction has to be performed before commencing urethral

reconstruction; short and undeveloped urethral plate has to be excised to allow the penis to be completely straightened. Some surgeons advocate splitting the neurovascular bundle elements to prevent nerve injury, but in cases of multiple or “S” shape curvatures, the neurovascular bundle should be lifted as a whole and curvature corrected on more than one level. In children, curvature repair is performed using the scarification of the tunica albuginea and plication with absorbable monofilament sutures. However, in adolescents and adults, different variants of the plication technique can be used to repair the penile curvature [45]. Several authors also mentioned a lengthening procedure i.e., grafting of the ventral side, such as a repair of acquired curvature in Peyronie’s disease. Recommended material is the same: tunica vaginalis, buccal mucosa, skin or synthetic grafts [41]. Finally, in more difficult cases, when short neourethra causes severe ventral curvature, additional one or two-stage urethroplasty must be performed.

9.11 Trapped Penis

In hypospadias anatomy, the ventral aspect of the penis is deficient in comparison to the dorsal. Lack of skin on the ventral penile side, accompanied by poorly developed blood supply and inadequate skin elasticity, pose a great challenge in hypospadias repair. In distal forms, dartos flap is mobilized and transposed ventrally to cover the suture lines of the reconstructed urethra, while the remaining dorsal skin is used to reconstruct the penile shaft. The repair of proximal hypospadias, where more than two procedures will be needed to reach a satisfying outcome, presents a special challenge. During hypospadias repair the tissue from the dorsal penile side is transposed ventrally to reconstruct the defects. In proximal forms, there is a need to reconstruct the entire urethra, as well as penile skin and to obtain a normal penoscrotal angle with a normal appearance of the genitalia. Some degree of skin necrosis can occur because of irregular blood supply. In the majority of cases, this necrotic field is superficial and usually heals by secondary intention; however, sometimes a

secondary skin repair may be required to prevent penile deformity and skin deficiency.

When treating an adult patient with secondary trapped penis due to multiple hypospadias repairs, the decision is made depending on the particular circumstances of each individual case. Penile skin reconstruction has to be performed with the penis in erect state, and can be completed using either vascularized flaps, usually originating from the scrotum, or free skin grafts originating from lower abdomen or thigh. In cases of severe penile skin shortage, two stage procedure with “penis burying” into the scrotum is one of the options that yields good results, though normal voiding and sexual intercourse during the healing period are compromised because of penis entrapment and its downward position [41] (Fig. 9.4a–d).

9.12 “Cripple” Penis

Hypospadias cripple is the most complex and the most challenging acquired penile anomaly for the reconstructive urologist. The term, however, is insulting for the patients who have had multiple unsuccessful hypospadias repair. These patients are usually subject to the highest complication rates [6]. The treatment is specific, as it has to cover both the functional and esthetic aspects of the penis. A problem that usually arises is a lack of healthy tissue availability and psychological aspects, with the patient wondering: Will the surgery fail again? There are no written surgical steps and approaches in cripple penis treatment, except one: do not use the same approach that failed more than once.

Patients with hypospadias cripple have usually undergone multiple failed repairs and still have a meatus positioned somewhere on the ventral aspect of the penis; the penile glans is typically deformed, with a glans tilt and with scars that do not allow for a regular glansplasty with the use of glans wings. There is an abundance of scarred, thin and inelastic skin along the penile shaft, which usually cannot be of great use in urethral reconstruction. The use of grafting techniques can also be in question because of the compromised vascularization of the surrounding tissues [24].

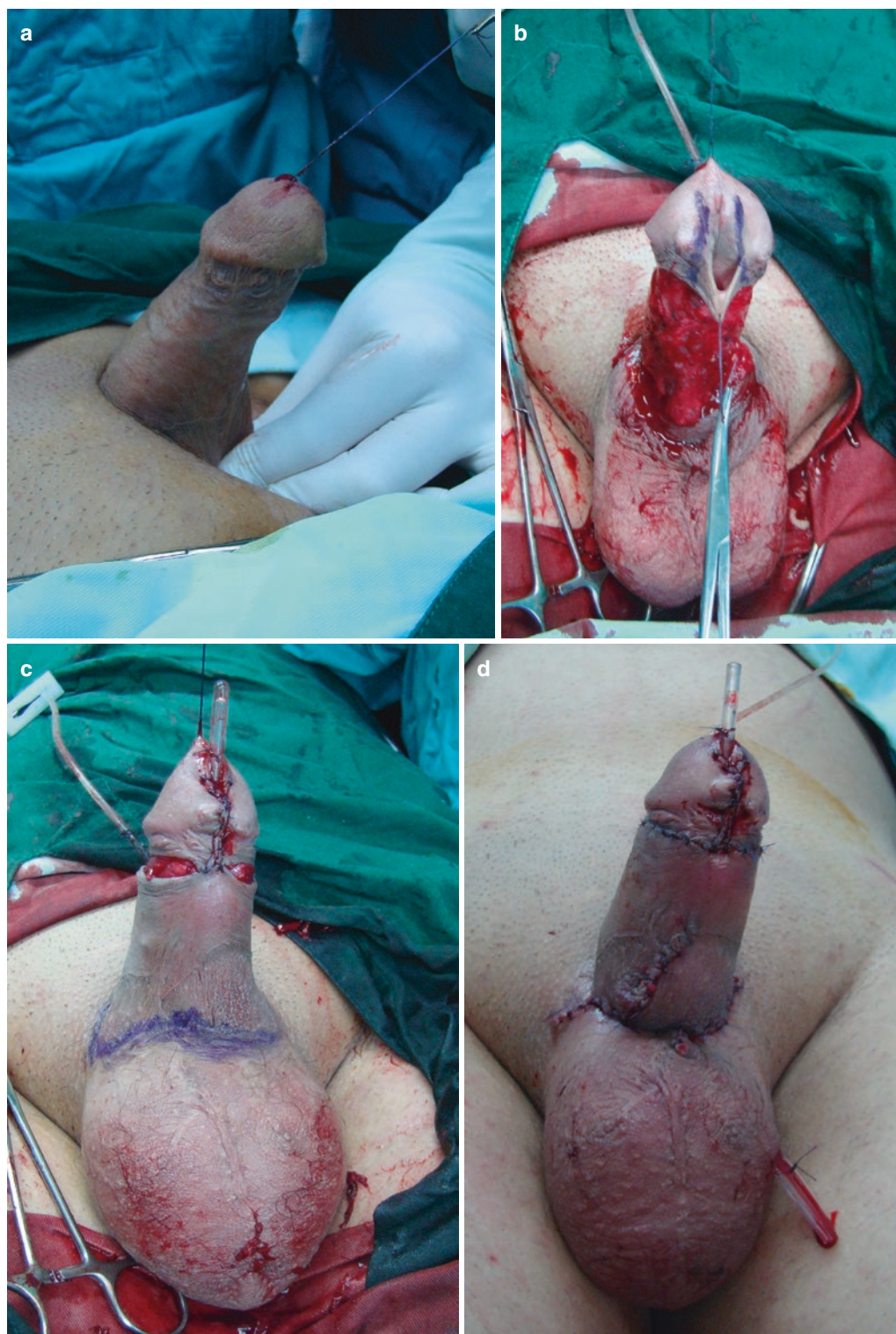


Fig. 9.4 Trapped penis. (a) Preoperative appearance. (b) Penile degloving. Glanular urethra is missing. (c) Glansplasty. Marked lines showing short penile skin. (d)

Outcome at the end of surgery – penile shaft reconstructed using scrotal skin flaps. Normal penoscrotal angle is obtained

Uroflowmetry and VCUG should be performed to evaluate the micturition problems and length of the urethral stricture before surgical treatment. LS presence implies that any form of skin urethroplasty is contraindicated. Presence of urethral fistula should be noted, as well as presence of any other intraurethral pathology (exp. stones, hair, diverticulum, etc.).

Penile degloving must be performed and all scar tissue should be removed with the aim to reach the healthy structures. If the urethra is short and fibrotic, it must be excised and artificial erection performed to evaluate the presence of residual curvature (Fig. 9.5a–d). Residual curvature must be repaired by one of the previously described approaches. To ensure a successful urethral repair of the hypospadias cripple, we need to create urethra grafts of adequate size, usually originating from oral mucosa. In the majority of hypospadias cripple, the glanular urethra is created by glans augmentation with a buccal mucosa graft that is placed and fixed to the incised glans [25]. When the dorsal penile skin availability allows, the safest reconstruction is one-stage urethroplasty with buccal mucosa graft quilted to the tunica albuginea of the straightened penis in combination with a dorsal island skin flap transposed ventrally [13, 37]. In case the two stage urethral reconstruction is performed, the oral mucosa graft must be wider than the defect as it may shrink in 3–6 months' time when tubularization of the neo-urethral plate should be performed [39]. The patient should be advised to keep the oral mucosa graft elastic and scar free in order to guarantee the future urethroplasty [24, 46].

Multiple failed hypospadias repairs only delay the satisfaction and psychosexual functioning of the patients, especially if the treatment was performed at an older age, when genital awareness is formed. Patients with hypospadias cripple suffer from psychological difficulties in addition to functional and aesthetic problems. They are usually shy, may have enuresis problems, depression, anxiety, and they enter into sexual relationships later; this is why psychological counseling is of great importance [6].

9.13 Summary

When it comes to adult hypospadias treatment, there are many challenges facing reconstructive urologists. Primary repair with healthy and scar-free tissue is somewhat easier and with a higher success rate, as reported in literature when compared to patients with failed hypospadias and prior multiple repairs [16, 21]. In addition, adult patients, as mentioned before, have more frequent erections, less tissue availability for hypospadias repair, urethral plate rich in collagen fibers, fewer elastic fibers, delayed epithelization because of impaired migration and proliferation, thinner dartos fascia, and intraurethral secretions that, all together, can contribute to poor healing with subsequent complications [8]. Studies dealing with adult hypospadias repair usually do not have a great number of patients undergoing primary repair, but those available showed higher incidence of urethral complications [16, 21]. Hence, hypospadias repair in adult patients always comes with a risk of failure, even after primary surgery.

Literature is also short in studies with long-term follow-up of initially successful hypospadias repair in childhood, as majority of patients are lost to follow-up, or do not go to the treating surgeon. Transitional urology aims to make a connection between the pediatric and adult urologists to provide constant monitoring of patients with congenital urogenital anomalies [5, 6, 47].

When considering the surgical approach to adult patients with hypospadias, we need to keep in mind prior treatment, if any, but also the patients' expectations regarding the final outcome. It is our duty to ensure the patients' acceptance of staged repair when necessary, with a delayed satisfactory result. Psychological counseling of the patient and his family plays an important role in overall treatment [48].

Successful outcome of hypospadias repair is not characterized only by urethroplasty with an orthotopic meatus, but also with a completely straight and good sized penis, conically shaped glans, preserved function and esthetically acceptable appearance that are all together important for satisfactory body image development and normal psychosexual functioning [41].



Fig. 9.5 Hypospadias cripple. (a) Preoperative appearance. (b) Short penis, trapped under the skin. (c) After penile degloving, artificial erection shows a persistent penile curvature. (d) Outcome at the end of surgery.

Curvature is corrected, leaving a straight and lengthened penis. Urethral opening is at the penoscrotal angle, as a temporary urethrostomy

Key Summary Points

- Hypospadias repair should be performed as early as possible to lessen stress and trauma related to genital surgery.
- Whenever possible opt for one-stage repair rather than two-stage repair.
- It is important to check and correct penile curvature during the primary repair and to prevent recurrence.
- Two-stage repair should be reserved for prior failed surgeries to minimize the percentage of possible new complications related to inelasticity of tissue or lack of available tissue for an adequate reconstruction.
- Long-term follow-up of patients treated for hypospadias is necessary until genital maturity so that possible complications could be diagnosed and repaired in time.
- Psychological counseling can be helpful in adolescents and adults encountering sexual dysfunction and mutilated genitals.
- Reoperative hypospadias surgery in adults should be centralized in tertiary reconstructive urology centers, where adequate knowledge and care can be provided to patients, as well as an adequate long-term follow-up.
- Hypospadias cripple repair should include the removal of all scarred tissue together with the correction of all penile deformities and urethroplasty in a safe procedure. In very difficult cases, two-stage repair is the only possible method for a successful outcome.
- Fertility examination should be advised to all men with hypospadias who had additional genital anomalies (undescended testis, hernia...).

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Conflict of Interests The Authors declare no conflict of interest.

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Surgical Reconstruction of Penile Urethral Strictures: Single-Stage Procedures

10

Guido Barbagli and Enzo Palminteri

10.1 Introduction

The aetiology of penile urethral strictures include many causes, with a significant differences between developing and developed countries. In developing countries, post-infectious (*Neisseria gonorrhoea*) strictures still represent the cause of the majority of penile strictures, but post-instrumentation/catheter related strictures are increasing [1–3]. Developed countries showed a decrease in infective aetiology and an increase of catheter, instrumentation, idiopathic causes, lichen sclerosus (LS) and failed hypospadias repair (FHR) related strictures [4–6].

Penile urethral strictures are managed by using a one or two-stage repair. Complete obliteration of the external urethral meatus with wood-hard fibrosis extending into the penile tract or complex strictures associated with fistulae, scarring, chordee, abnormal meatus, small glans and deficiency of the dartos layer are better managed by using a staged reconstruction [7–9]. In one-stage penile urethroplasty the use of a flap or graft is still a debated issue [10]. In recent years,

the use of a graft for anterior urethroplasty has become the most popular option for any augmentation tissue repair [10]. However, the current literature is too limited to answer the question of whether a flap or graft is superior for one-stage penile urethroplasty, including only a collection of retrospective series of patients or meta-analysis studies with a variable definition of the stricture recurrence and successful outcomes [10]. The success rates of penile urethroplasty using a flap or graft are reported to be similar [10].

The aim of this chapter is to describe the history and evolution of the surgical reconstruction of penile urethral strictures using single-stage procedures, including the new surgical innovations.

10.2 Historical Background

10.2.1 History and Evolution of Penile Skin Flap Urethroplasty

In 1968, Orandi described a new one-stage urethroplasty utilizing the principles of pedicled skin grafting for repair of penile and bulbar urethral strictures [11]. A skin incision is made at the level of the stricture, the urethra is ventrally opened in the midline and the desired penile skin graft is tailored according to the stricture length and inverted and sutured over the urethral defect [11]. The inverted skin graft will have ample

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mobility despite its long and wide attachments to the dartos fascia [11]. In 1972, Orandi reported the results of this original technique on 14 patients showing that one patient developed stricture recurrence and two patients grew hair and formed stones over the grafted area, requiring transurethral removal and revision [12].

However, the technique described by Orandi is not completely original because in 1962 Leadbetter et al. referred to a method of letting in an island of skin based on a pedicled dartos fascia to repair penile strictures in children [13]. Turner-Warwick in 1972 and Blandy in 1975 described some important changes to Orandi's technique [14, 15]. In 1985, Webster et al., reported the results on 11 patients treated by using vascularized island skin flap urethroplasties suggesting that the results appear to be excellent when the procedure is used for penile stricture repair, but the use of vascularized skin flap urethroplasties for repair of bulbar and membranous strictures has been complicated by pseudodiverticula and stone formation [16]. Anyway, for many years, the Orandi's technique represented the milestone for treatment of penile urethral strictures.

In 1983, Quartey described an original technique for a single-stage urethroplasty using a transverse distal penile-preputial cutaneous island flap, similar to the technique described by Duckett for hypospadias repair [17]. In 1985, Quartey reported the results of this technique in 27 patients with stricture recurrence in six patients and diverticulum formation in five [18]. In 1997, Quartey fully described the microcirculation of penile and scrotal skin as anatomical basis of this technique [19]. The Quartey's technique become one of the most popular procedures for urethral stricture repair used in African countries.

In the 1980s and 1990s, the use of a penile skin flap for single-stage penile urethroplasty was the most commonly used technique and Hinman Jr. fully described the anatomical and vascular basis of these techniques [20].

In 1993, McAninch described a new technique for one-stage repair of long penile and peno-bulbar urethral strictures using a circular fasciocutaneous penile skin flap based on Buck's

fascia as the major vascular supply [21]. The surgical anatomy and the harvesting flap technique was fully described by McAninch and Morey in 1997 and 1998 [22, 23]. In 2008, Whitson et al. reported the long-term efficacy of distal penile circular fasciocutaneous flap for one-stage repair of complex anterior urethral strictures [24]. A total of 124 patients were included in the study with a median follow-up of 7.3 years (range 1 month to 19.5 years), median stricture length was 8.2 cm (range 0.5–24), and at 1, 3, 5 and 10 years the overall success rates were 95%, 89%, 84% and 79%, respectively [24]. Smoking, failed hypospadias repair and stricture length >7 cm were predictive of failure [24]. Hematoma, urinary extravasation, penile skin necrosis, decrease in penile sensation were the most frequent reported complications [24].

The McAninch's technique, even now, represents one of the most popular procedures for the repair of long complex penile or peno-bulbar urethral strictures.

10.2.2 History and Evolution of Penile Graft Urethroplasty

The use of free skin grafts for single-stage anterior urethroplasty was reported many years before the use of pedicled skin flaps. In 1953, Presman and Greenfield described the use of a free skin graft for reconstruction of the perineal urethra in one patient, with successful outcome [25].

In 1963, Devine et al. started in popularizing the use of free full-thickness skin grafts for penile and bulbar urethroplasty, describing original techniques [26–29]. The Devine and coworker's articles represent a milestone in the history and evolution of the use of penile free skin grafts for anterior urethroplasty.

In 1984, Webster et al. reported excellent results in 18 cases in which a penile skin donor site was.

used and three failures in which the full thickness grafts were raised from the inner aspect of the upper arm, and suggested caution when extra penile skin is used for such repairs [30].

For many years, penile skin was the preferred tissue suggested for single-stage urethroplasty.

A great evolution in the techniques using free grafts was in 1993, when El-Kassaby et al. reported the first series of 20 adult patients with penile (12) or bulbar (8) urethral strictures treated by transplanting an oral mucosa graft, with high success rate [31]. These authors reported that they started using this technique in 1975, without suggesting why they decided to use the oral mucosa, but they had known and reported an article on the use of oral mucosa in ophthalmology [31]. We can suppose that this article was the first after the pioneering report from Kirill Sapezhko in 1894 [32]. However, it would be interesting to know why these authors started using this innovative surgery in 1975 and only described it in 1993, 18 years after their first application [31]. Nevertheless, this report represents a milestone in the history of the use of oral mucosa for urethroplasty. In 1996, Wessells and McAninch, reported the outcomes on 35 patients who underwent penile or bulbar urethroplasty using free grafts (penile skin, oral mucosa, bladder mucosa) and suggested that oral mucosa provided higher success rate when compared to penile skin [33].

A great evolution on the use of oral mucosa graft for penile urethroplasty started in 1996, when Barbagli et al. first described a dorsal approach to the urethral lumen for reconstruction [34]. As far as the penile urethroplasty is concerned, the most important improvement of the Barbagli's dorsal approach was suggested by Asopa et al. in 2001 [35]. These authors described a new fascinating penile single-stage reconstruction utilizing the Snodgrass, Hayes and Malone techniques used for hypospadias repair [35–37]. On this technique, the penile urethra is fully exposed, and the urethral plate is longitudinally incised to create a wide window for oral mucosal graft placement [35]. In 2016, Barbagli et al. described a new modification of the Asopa's technique for penile urethroplasty using a new glue for graft fixation inside the incised urethral plate, reporting an 85.7% success rate [38].

10.3 Single-Stage Penile Skin Flap Urethroplasty

The decision to perform a penile pedicled skin flap urethroplasty or free oral mucosal graft is based on surgeon preference and background.

The use of pedicled vascularized penile skin flap is mainly suggested in patients with penile urethral strictures showing a narrow and fibrous urethral plate not ideal for a transplant of free graft. In patients who developed recurrent stricture after Asopa's free graft urethroplasty, the use of a vascularized penile skin flap should be the preferred choice. In patients with LS genital skin disease the use of a penile flap should be avoided. In patients with failed hypospadias repair, the dartos fascia will be fibrous, thin and not adequate for vascular support to the skin island flap.

One of the most frequent complications of the classical Orandi's flap technique is the development of postoperative diverticulum, because the skin flap is sutured over the ventral urethral surface without adequate covering from the corpus spongiosum. For this reason, we developed a placement of the pedicled skin flap on the dorsal urethral surface avoiding postoperative diverticulum formation (Fig. 10.1a–h). The use of the penile skin flap may cause penile or gland torsion due to the rotation of the penis along the vascular pedicle.

10.4 Single-Stage Penile Oral Mucosal Graft Urethroplasty

Single-stage urethroplasty using a free oral mucosal graft should be performed in the majority of patients presenting with penile urethral strictures. This technique should also be used in selected patients with single penile strictures related to genital LS, because LS rarely involves the oral mucosa. This technique is not suggested in patients with failed hypospadias repair showing a scarred, fibrous and thin urethral plate.

The penile urethra should be approached by using a sub-coronal circumcision incision (stricture located in the distal part of the penis),

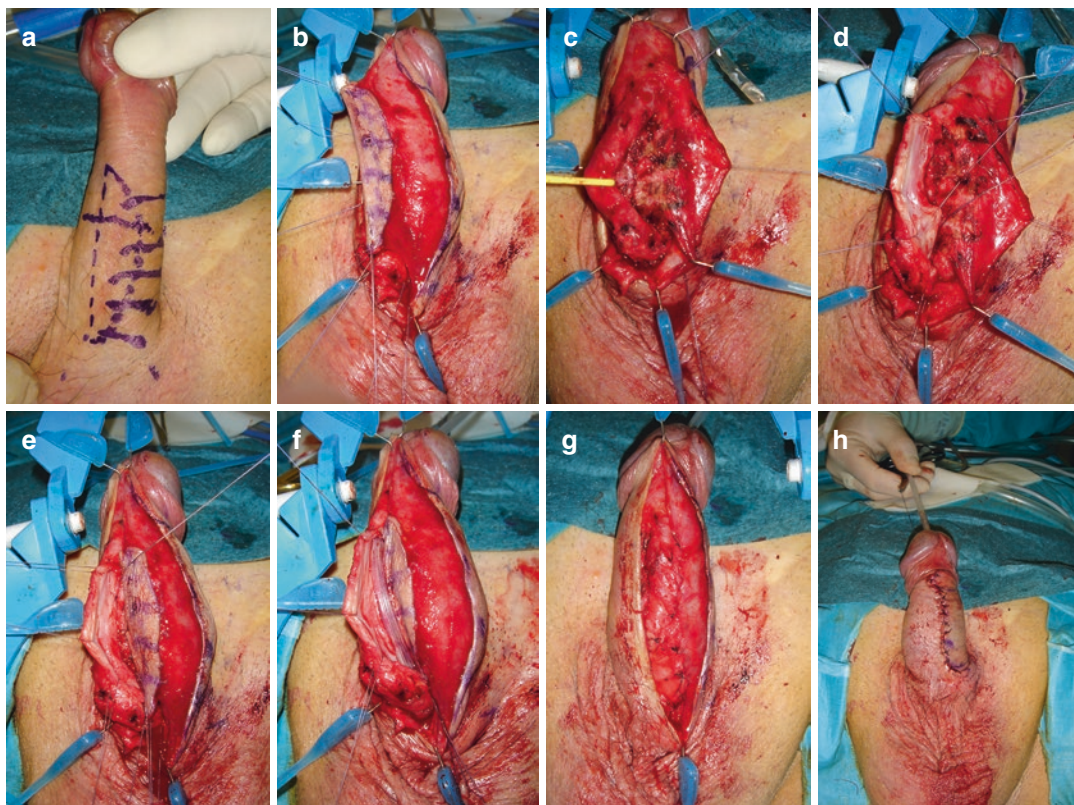


Fig. 10.1 (a) The site of stricture is identified and the penile skin incision is outlined showing the skin flap and its vascular support. (b) The penile skin island is developed based on the dartos fascia. (c) The penile urethra is fully dissected from the corpora cavernosa. (d) The urethra is rotated to expose the dorsal surface and fully opened. (e) The penile skin island is moved over the corpora cavernosa,

next to the urethral mucosa. (f) The penile skin island is fixed to the corpora cavernosa and sutured to the urethral mucosa margin. A Foley 12 Ch. silicone catheter is inserted. (g) The urethra is fully rotated over the skin flap and sutured to the corpora cavernosa. (h) The penile skin is closed over the urethra

longitudinal midline incision (stricture on the middle part of the penis), perineal incision with invagination of the penis into the perineal approach (stricture in the basis of the penis). The use of glue to fix the graft simplifies the procedure and greatly reduces the surgery time (Fig. 10.2a–n). The main advantage of the use of this technique is that it is easy and safe using the perineal approach, thereby avoiding any complications in the penile shaft (Fig. 10.3a–h). One post-operative complication of this technique is a urethral fistula which will be evident during the first postoperative radiological investigation. It will be sufficient to insert a new small catheter in the urethra and perform a

radiological investigation after 3 weeks. In our experience, 100% of fistulae spontaneously closed after prolonged catheterization.

10.5 Discussion

Single-stage repairs of penile urethral strictures continue to evolve, and there is no definitive answer regarding the superiority of one approach over another.

Graft vs. Flap. The use of one-stage repair using a flap or graft is under debate [10]. The popularity of flaps versus grafts has varied over time, and lately, free grafts have been making a

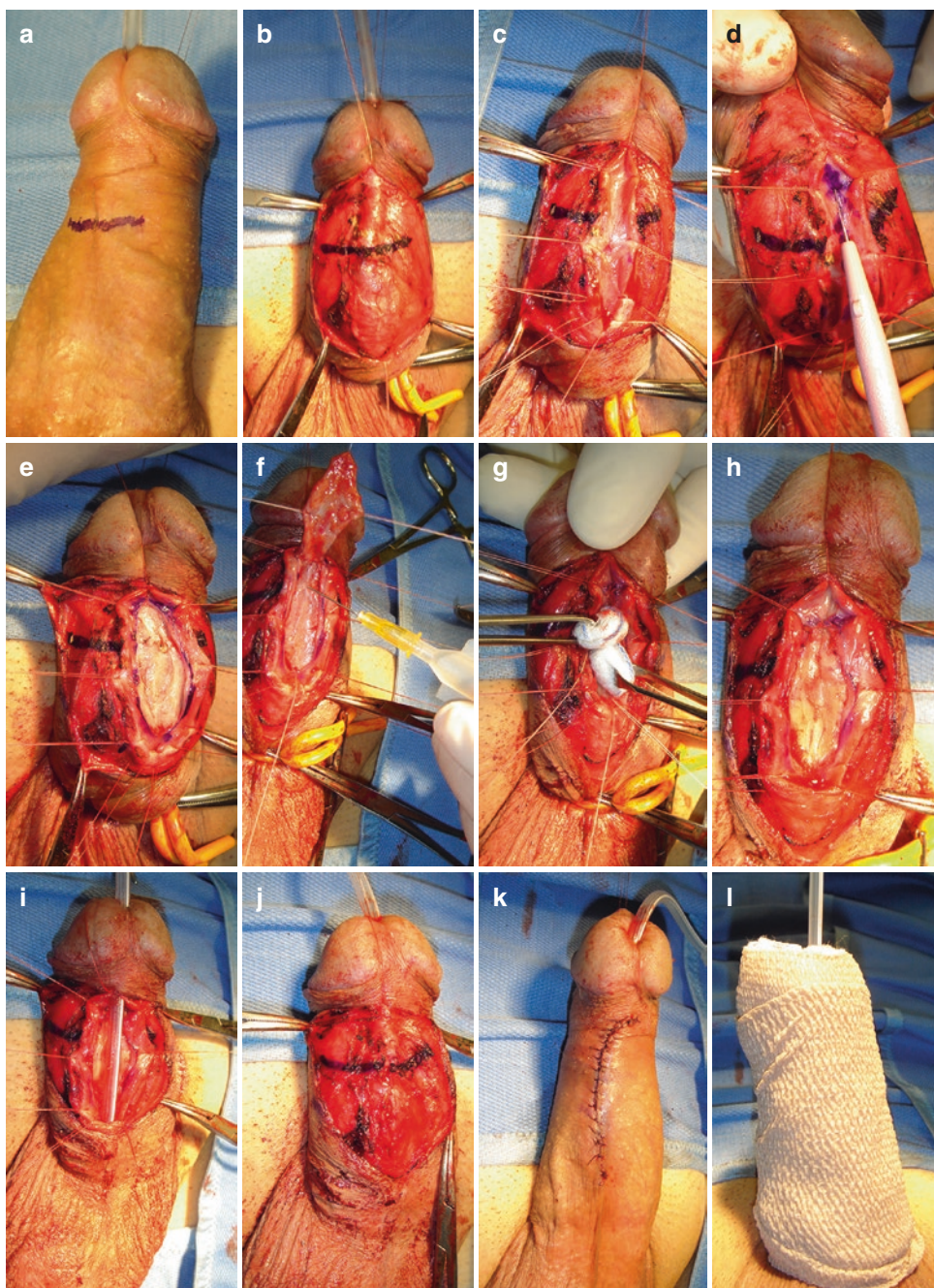


Fig. 10.2 (a) The penile stricture site is identified using atraumatic plastic Nelaton 12 Ch. catheter. (b) After the penile skin incision and fully exposure of the urethra the stricture site is identified. (c) The urethra is longitudinally opened along its ventral surface. (d) A midline incision of the mucosal urethral plate is performed using ophthalmic scalpel. (e) A wide window in the mucosal urethral plate is create. (f) The oral mucosal graft is sutured to the distal

incision of the urethral plate and the glue is injected on the window inside the urethral plate. (g) The oral mucosa graft is put down over the glue bed and compressed for 45 seconds. (h) The graft is well distended and no quilted sutures over the graft are used. (i) A Foley 12 Ch. silicone catheter is inserted. (j) The urethra is closed over the catheter. (k) The penile skin is closed over the urethra. (l) A light compressive dressing is performed

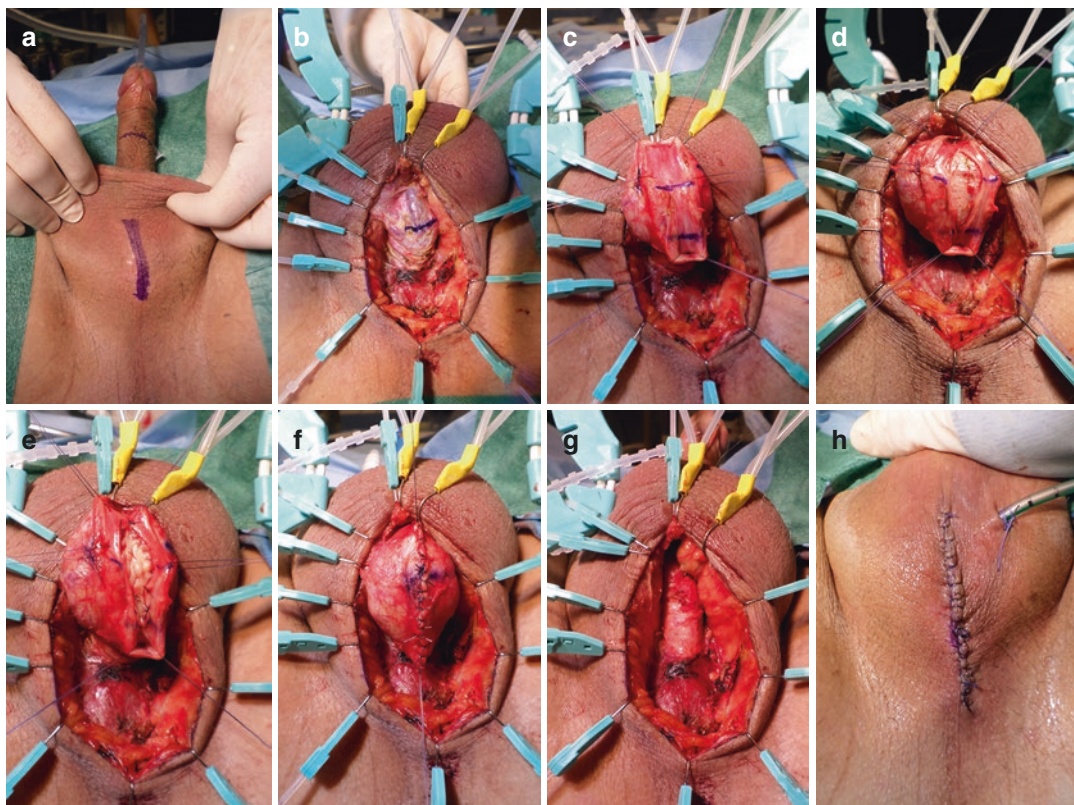


Fig. 10.3 (a) The site of penile stricture is identified and the perineal skin incision is outlined. (b) The penis is pulled down the perineum and the site of stricture is again identified. (c) The penile urethra is longitudinally opened along its ventral surface and the stricture is identified. (d) A midline incision of the mucosal urethral plate is performed, and a wide window in the mucosal urethral plate

is create. (e) The oral graft is fixed into the oral mucosa window. (f) A Foley 12 Ch. silicone catheter is inserted, and the urethra is closed over the catheter. (g) The penis is tight on its original position and the suture lines are now outside of the perineal incision. (h) The perineal incision is closed leaving a small drainage

comeback, with fewer surgeons using genital flaps [33, 39, 40]. However, only a few prospective studies have compared the graft with the flap, making it hard to declare a clear winner. In general, the success rate reported for one-stage free graft penile urethroplasties ranges from 24% to 57%, and in one-stage penile flap urethroplasties it ranges from 14% to 100% [41–44]. On the other hand the literature is characterized by a few articles with a small series of patients and short-term follow up.

In the past penile skin flaps were preferred because it was believed that a scarred spongiosum and poor vascularity of the pendulous ure-

thra would not support graft take [33, 39]. These concerns may have been pertinent in an era when grafts were exclusively applied on the ventral aspect. In the dorsal position grafts have the advantage of a secure scaffold in the corpora cavernosa which also forms a substantial portion of the graft bed. The viability of the engrafted tissue depends on the degree of neovascularization: experimental studies showed that the angiogenic activity is highest in oral mucosa grafts compared to penile skin grafts or flaps [40].

In his study Dubey stated that, compared to oral mucosa, penile skin flap procedures are technically complex, associated with higher morbidity

and less preferred by patients; their mean operative time was significantly higher in the penile flap (224 minutes) vs. the oral mucosa group (162 minutes) [40].

In reality, the reconstructive surgeon must be familiar with the use of both flaps and grafts in order to deal with any condition of the urethra. However, the use of grafts can be readily acquired and does not require extensive training in tissue transfer procedures, as is required with the use of penile flaps. Furthermore, flap urethroplasty is characterized by a higher rate of penile complications than graft urethroplasty (penile edema and hematoma, skin necrosis, scars, chordee, penile rotation), with an important social and psychological impact on the quality of sexual life. Finally, in patients with failed hypospadias repair or LS the shortage of dartos and skin or the skin disease make it impossible to use penile flaps.

Dorsal vs. Ventral augmentation. Clinical evidence suggests that the ventral penile tissues and spongiosum do not provide ideal vascular and mechanical support for ventral grafts, therefore the preferred approach to augmenting the penile urethra is to use dorsal wall inlay procedures [33].

Furthermore the most frequent complication of the ventral flap technique is the development of a diverticulum, because the skin flap is sutured over the ventral urethral surface without adequate covering from the spongiosum.

Oral mucosa vs. Penile skin. In recent years, the literature seemed to support the soundness of oral mucosa graft for urethral stricture repairs. Oral mucosa grafts are quicker and easier to prepare than skin (grafts or flaps) and less prone to problems; still there is a difference in the restriction rate between using oral mucosa graft or a skin (graft or flap) – assuming that the patch is placed dorsally [40, 45]. Oral mucosa is characterized by great elasticity and handiness, and prevents the cosmetic disadvantages (penile torsion, penile scars, chordee) caused by using local genital skin.

In patients with LS, the use of oral mucosa as substitute material is mandatory: because LS is

a skin disease, any skin that would be used for the repair is already diseased or may become diseased [45–47]. In patients with failed hypospadias repair, the shortage of penile skin makes the use of the oral mucosa necessary. The harvesting of BM potentially adds to operating time, though not if a two-team approach is used, with the oral and urethral surgery proceeding simultaneously.

In our experience, the success rate of one-stage penile urethroplasty increased with the evolution of the surgical technique: 66.7% success rate using a skin flap, 78.3% success rate using a skin graft; 81.8% success rate using an oral graft, and 85.7% success rate using an oral mucosa graft and glue [48]. The current results, however, don't offer any evidence for graft vs. flap and we believe that the choice should be based on stricture characteristics, surgeon background and preference [7–10, 49].

10.6 Conclusions

Repair of penile urethral strictures is a challenging problem for which different techniques have been suggested. One-stage reconstruction of penile urethral strictures with an oral mucosa graft and glue showed that the procedure is safe and efficient, but further studies including larger series of patients and longer follow-up are required. In the recent years, we have greatly changed and improved our techniques for repairing penile strictures. Using the non-invasive techniques we presented here any surgeon will be able to repair the majority of simple (one-stage repair) or complex (two-stage repair) penile strictures of any etiology. Oral mucosa seems to be a little better than skin graft material, but the differences may not justify the use of one over the other as a first choice. The choice of surgical technique (graft vs. flap) should be based primarily on the condition of the urethra found intraoperatively. However, the surgical background and training of the surgeon also conditions the selection of the procedure.

Key Summary Points

- The surgical reconstruction of penile urethral strictures using a single-stage procedure should be offered to any patient showing favourable characteristics.
- The use of a pedicled skin flap or free graft should not compromise penile length, should not cause penile chordee and certainly should not untowardly affect penile appearance.
- The successful management of penile urethral strictures demands attention not only to surgical detail but to procedure selection. No single technique is appropriate for all situations and the successful surgeon will have a repertoire of operations to choose from.

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Surgical Reconstruction of Penile Urethral Strictures: Staged Procedures

11

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11.1 Introduction

Staged urethroplasty involves utilizing more than one surgical intervention in the treatment of urethral stricture, diverticulum or fistula. While single stage procedures are favored for obvious reasons, there is a well-established role for staged procedures. Indications include: strictures related to lichen sclerosis (LS), prior reconstructive surgery for hypospadias or urethral stricture, poor tissue quality or a paucity of viable genital skin for flap reconstruction, and an absent lumen precluding substitution urethroplasty. Current staged procedures involve tissue transfer, most commonly using buccal mucosa in the modern era [1, 3]. This chapter will outline the relevant preoperative evaluation in patients with penile urethral stricture or fistula, and describe the surgical technique and reported outcomes of staged urethroplasty for penile urethral reconstruction.

11.2 Preoperative Evaluation

The preoperative evaluation in patients being considered for urethral reconstruction is critical for adequate preoperative counsel and surgical

planning. Evaluation should include a detailed history with specific attention to pertinent pediatric urological history, prior surgical interventions, previous history of genitourinary trauma or infection, recent urethral instrumentation, current voiding pattern, and a history of urinary retention especially if associated with renal insufficiency. Additional important patient factors that should be documented include presence of urinary incontinence, erectile dysfunction or chordee, history of malignancy and relevant treatment modalities used (especially radiation), and oral pathology or tobacco use. The aforementioned list is by no means exhaustive, but rather a starting point to frame the subsequent discussion for treatment of urethral stricture. Physical examination is also key when deciding on surgical approach, especially for a penile urethral stricture. Assessment should include documentation of quality and availability of penile skin and soft tissue, circumcision status, location and severity of genital scars, and the presence of LS.

The next step is radiographic evaluation and typically includes a retrograde urethrogram (RUG) with or without voiding cystourethrogram (VCUG) to understand stricture length, location and other associated urethral or bladder abnormalities (Fig. 11.1). In an optimal situation, we prefer to wait at least 6–12 weeks following last urethral instrumentation to proceed with imaging to allow stricture maturation. If a VCUG is needed to fully evaluate proximal urethral anatomy, the bladder may be

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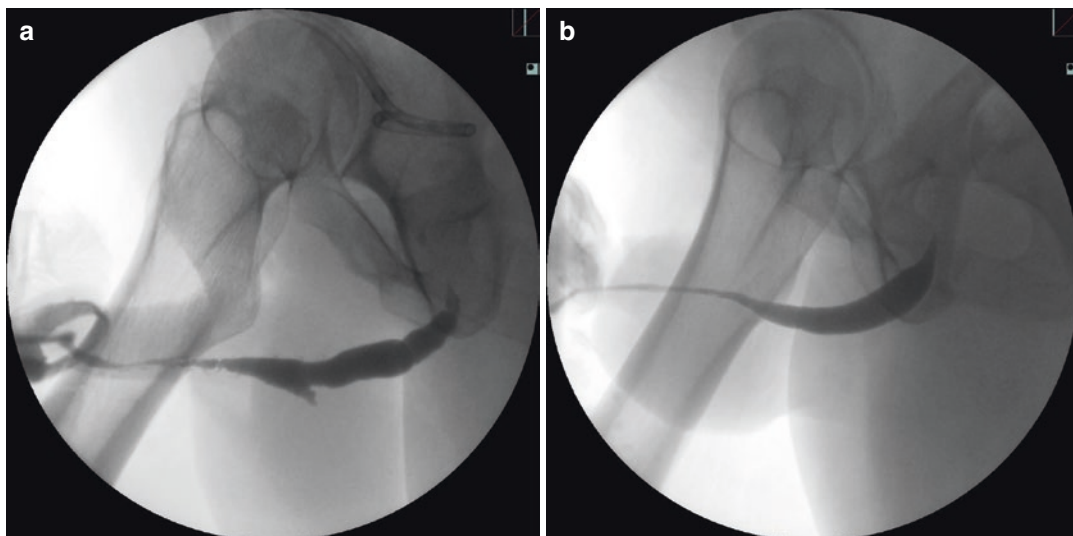


Fig. 11.1 Penile urethral stricture related to: (a) multiple prior surgical procedures for penoscrotal hypospadias and subsequent complications, (b) lichen sclerosis (LS)

filled with a Glidewire and open end catheter, or a suprapubic catheter placed to aid the procedure. Retrograde cystoscopy using a small caliber cystoscope or antegrade flexible cystoscopy are helpful confirmatory measures in select cases.

Managing expectations and helping the patient understand the timeline for urethral reconstruction is integral to the success of the operation. The period of urethral rest prior to the first stage procedure must be discussed, as well as a possible need for a suprapubic catheter to allow for this if the patient is requiring frequent dilation or performing self-catheterization. Between the first and second stage, a period of 4–6 months is typical for graft take and stabilization, and the patient needs to understand the process of sitting to void through a penile or upper scrotal urethrostomy during this time. Sexual intercourse is allowed approximately 6–8 weeks after the first procedure, and the patient is made aware that semen will also emanate from the urethrostomy. Following the second stage procedure, a catheter or urethral stent is left in the urethra for a period of 18–21 days to permit urinary diversion and urethral healing. Intercourse is again allowed after 6–8 weeks. From a surgical standpoint, patients must also understand the longer term risks of stricture recurrence, urethral fistula or

diverticulum, spraying of the urinary stream, and potential need for additional procedures.

11.3 Surgical Technique: First Stage for Penile Stricture

The patient is placed in the supine position for penile urethral reconstruction, but in dorsal lithotomy if there is to be concurrent work on the bulbar urethra or for a panurethral stricture. If there is an area of the reconstruction where penile skin may need to be incorporated, attention should be paid to hair pattern to ensure use of non-hair bearing tissue in the final repair. After the patient is prepped and draped, a glans traction suture is placed to assist with surgical exposure. The incision is then marked out along the ventral penis in the midline, incorporating the urethral meatus and glans as needed, and may be extended proximally to the upper scrotum along the midline raphe depending on stricture length. To confirm the distal limit of the stricture, a 20–22F bougie is placed in the urethral meatus and advanced to the point of resistance. An incision is made through the skin and dartos and then into the urethral lumen. The penile incision and the urethrotomy are extended through the entire length of the stricture until healthy wide caliber

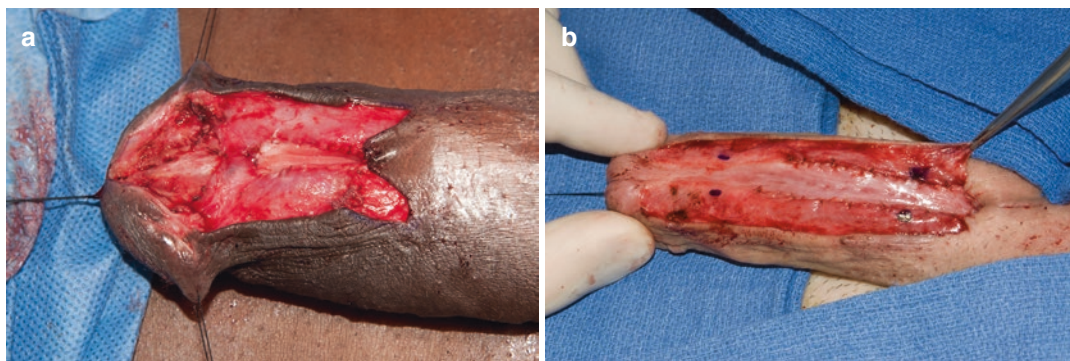


Fig. 11.2 (a) Urethral excision and urethrostomy in patient following prior distal hypospadias repair; (b) Urethrotomy and penoscrotal urethrostomy in setting of LS

urethra is encountered. This maneuver is aided by passage of a Glidewire or open end catheter in some cases. Once healthy normal caliber urethra is reached, urethrostomy is performed by suturing adjacent genital skin to the spatulated urethral opening full-thickness using 4-0 or 5-0 Vicryl (Fig. 11.2). If the penobulbar junction has been reached within the upper scrotum and more proximal ongoing stricture within the bulbar urethra is identified, this can usually be reconstructed using a one-stage type repair using a ventral or dorsal onlay of oral mucosa with the urethrostomy created at the distal end of the bulbar repair (Fig. 11.3). The legs are raised within adjustable stirrups to allow a separate perineal incision for this part of the procedure. For any stricture, flexible cystourethroscopy is recommended to evaluate the proximal urethra and bladder once normal caliber urethra is reached.

Once the above has been completed and urethrostomy established, the existing urethral plate is then examined. Portions of the urethral plate may require complete excision if severely diseased, obliterated or hair-bearing. However we have found that significant portions of the urethral plate, usually starting just proximal to the level of the corona, often appear viable and may be preserved and greatly aid second stage tubularization even in the setting of LS (Fig. 11.4). Prior to grafting, a 5-0 running absorbable suture may be used to close the edges of the corpus spongiosum and urethral mucosa on each side to aid hemostasis. In some cases it is necessary to mobilize and rotate some of the adjacent dartos and tack it medially to the urethral plate to optimize the graft bed, and aid subsequent graft

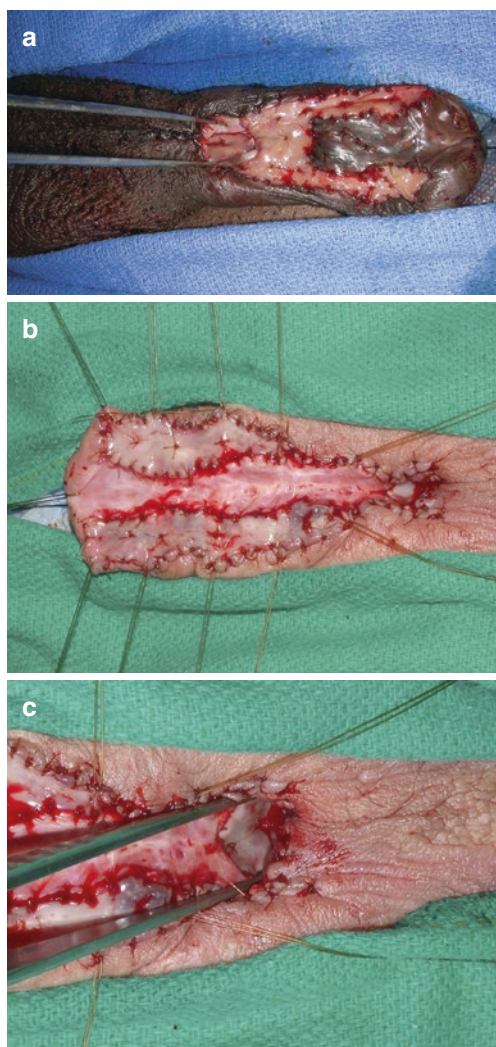


Fig. 11.3 (a) Complex first stage hypospadias patient with proximal dorsal buccal mucosa graft seen between forceps at proximal urethrostomy; (b) Proximal dorsal graft at urethrostomy opening for extensive LS stricture; (c) Closer view of urethrostomy and graft

mobility and tension-free closure. The length of graft needed for penile urethral reconstruction is then measured. In a patient with a normally virilized phallus, we try to obtain a final urethral plate of approximately 3 cm width for optimal tubularization, although this is not always quite possible within the glans. A prepubertal phallus may



Fig. 11.4 Excision of distal stricture with preservation of remainder of urethral plate proximal to the corona in patient with LS – note suturing of proximal penile skin to urethra due to insufficient buccal mucosa at first stage

accommodate a smaller caliber urethra, particularly if the glans is diminutive, and adjustments are made accordingly. Oral mucosal is then harvested in the usual fashion, either from one inner cheek or both depending on the amount needed and oral anatomy. Once the buccal graft(s) are harvested and appropriately thinned, the mucosa is spread and fixed onto the opened glans and adjacent to the urethral plate using 4-0 or 5-0 absorbable sutures peripherally, following by multiple quilting sutures to aid apposition and take. The graft(s) can be configured along either side of the urethral plate to fill in areas necessary to achieve the desired width symmetrically throughout the repair (Fig. 11.5). We have not routinely perforated our grafts. When the stricture involves the distal urethra into the glans, it is critical to ensure that the glans cleft is deep enough and glans flaps mobilized to provide a graft width adequate for closure at the second stage. In some forms of hypospadias or LS, the glans may be insufficient for adequate grafting, and in this instance a coronal or subcoronal

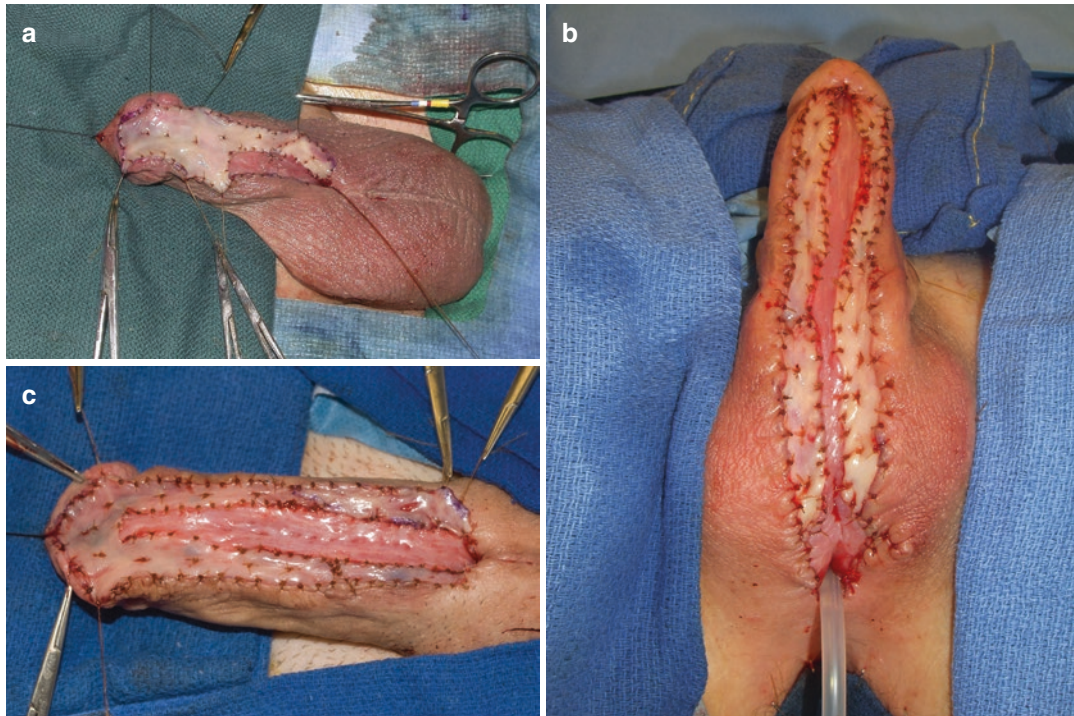


Fig. 11.5 (a) Complex hypospadias patient; (b) Panurethral stricture in patient with proximal hypospadias; (c) Lichen sclerososis

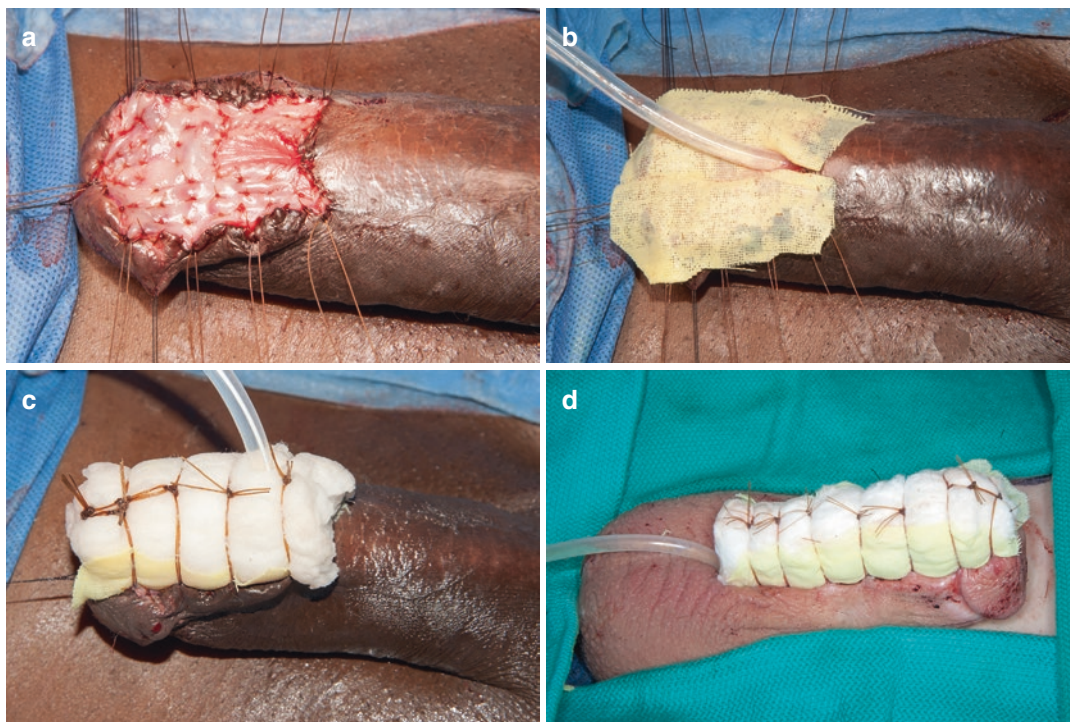


Fig. 11.6 Dressing: (a) Hypospadias patient with graft in place; (b) Xeroform gauze; (c) Bolster secured with tie-over sutures; (d) Completed dressing in LS patient with more extensive stricture

meatus may be more feasible after discussion with the patient. In the setting of a panurethral stricture, there may be a segment of urethral plate between the proximal one-stage repair and distal first-stage repair where there is no further buccal mucosa available. In this setting, we have preferred to suture adjacent proximal penile skin to the urethral plate to complete the first stage repair as opposed to harvesting additional tissue (Figs. 11.3b and 11.4). This segment can then be tubularized using lingual mucosa at the time of second stage closure, or by using the adjacent penile skin if no evidence of LS. Urethral catheter is inserted at this time, or in some cases a urethral stent if the repair is distal and a suprapubic catheter already present.

The dressing consists of Xeroform gauze applied to the grafted area, followed by a bolster made from artificial cotton soaked with a mixture of saline and mineral oil. The bolster dressing is secured in place with multiple tie-over 3-0 sutures that are tightened snugly to immobilize the graft

and prevent hematoma (Fig. 11.6). The bolster is removed 5–6 days following surgery, and we ask the patient to keep it dry and to stretch the graft during dressing changes 3 times daily using petroleum gauze. The urethral catheter is removed 2 weeks later, dressings are discontinued, and the patient allowed to shower and gradually resume activities. We recommend waiting until 2 months postoperatively before soaking in a tub or resuming sexual intercourse.

Although not as commonly used, in a setting where there is no oral mucosa available a meshed split thickness skin graft (STSG) may be substituted [14]. The procedure is similar up to the process of grafting, at which time an intermediate thickness STSG is harvested from the anterior thigh and then meshed, sutured and quilted into position (Fig. 11.7). The graft is generally larger in size than when using buccal mucosa as it tends to contract more. This technique should be avoided in the presence of LS. Postoperative care and management is as noted above.



Fig. 11.7 First stage mesh graft urethroplasty

11.4 Surgical Technique: Second Stage for Penile Stricture

The second stage urethroplasty is undertaken approximately 4–6 months after the first stage, however there is no time beyond which it cannot be done and some patients have waited longer to fit with their schedule. This permits maturation of suture lines, softening of the graft and development of microvascular support, and results in tissue that can be nicely mobilized for tubularization without tension. Flexible cystoscopy is performed to assess the urethrostomy and the proximal urethra, especially if a one-stage bulbar urethroplasty was performed at the first stage so that patency can be evaluated. The graft is then outlined and measured, ensuring that it is as close as possible to 3 cm in width throughout. As mentioned previously this incision may incorporate some hairless genital skin in order to achieve the desired width. Incision is made around the graft and around the urethrostomy proximally (Fig. 11.8). If there is an area of the graft that has contracted somewhat, additional grafting can be done at the time of second stage closure. We have most commonly done this distally in the subcoronal region bridging onto the proximal glans. Lingual mucosa or a remaining area of buccal mucosa if present may be utilized, usually as a dorsal inlay (Fig. 11.9). Another situation in which this is helpful is in the setting of panurethral stricture, when proximal penile skin was sutured to the urethral plate between distal and proximal grafts due to insuffi-

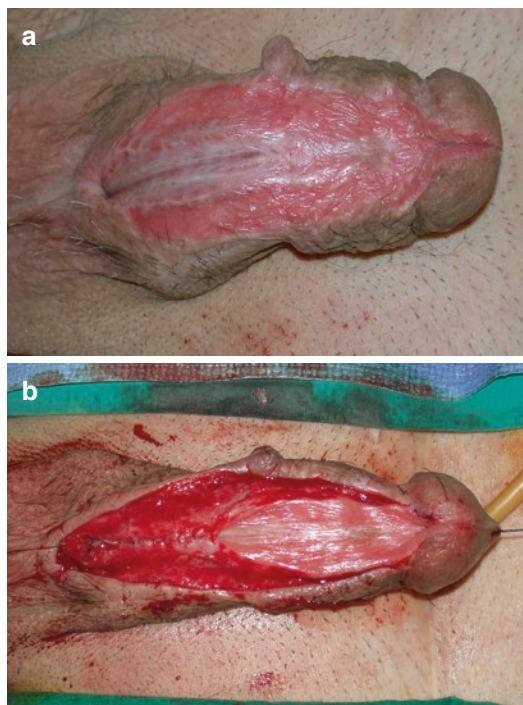


Fig. 11.8 (a) Well healed buccal graft in hypospadias patient; (b) Peripheral incision, mobilization of urethral plate, and initiation of closure



Fig. 11.9 Dorsal inlay of lingual mucosa to augment contracted glans graft at time of second stage tubularization

cient buccal mucosa for the entire repair. In this setting, we have most commonly used a 4–5 cm segment of lingual mucosa placed ventrally, followed by quilting to the overlying dartos during final closure. The urethral plate is then mobilized sufficiently so that it can be tubularized without

tension. It is important to do this carefully to preserve the blood supply to both the urethra and the adjacent penile skin during this maneuver. Tubularization of the urethra is then performed by placing sutures in an extra-epithelial fashion with a few interrupted sutures to align the repair followed by running 5-0 PDS. To reduce the risk of fistula, a second layer may be mobilized and secured. This can include surrounding dartos (if a sufficient amount is present), or a tunica vaginalis flap particularly in hypospadias related cases (Fig. 11.10). Glans flaps are created and the urethral closure is continued distally to a point where there is still an opening that calibrates to 22 or 24 French. The meatus is reconstructed on the glans if possible, but there may be some cases where a coronal or subcoronal meatus is acceptable as mentioned previously. For the urethral meatus, the glans wings are re-approximated using deep sutures of 4-0 PDS, followed by placement of interrupted 5-0 Vicryl sutures from the distal terminus of the tubularized graft to the glans. A 22-24 French bougie should be used intermittently as the urethra is closed to ensure adequate

caliber. Glans closure is completed in the midline using additional interrupted 5-0 Vicryl. The penile skin is closed in two layers, using interrupted 5-0 PDS on the subcutaneous dartos, taking care to avoid penoscrotal webbing (Fig. 11.11). In such cases, a Z-plasty may at times be helpful at the penoscrotal junction to avoid scar contraction. Penile skin closure is completed with interrupted

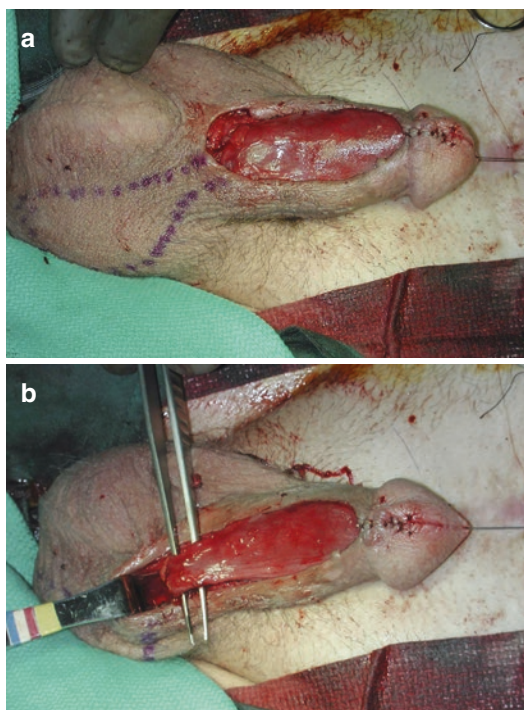


Fig. 11.10 (a) Tunical vaginalis flap in place for urethral coverage; (b) Pedicle demonstrated

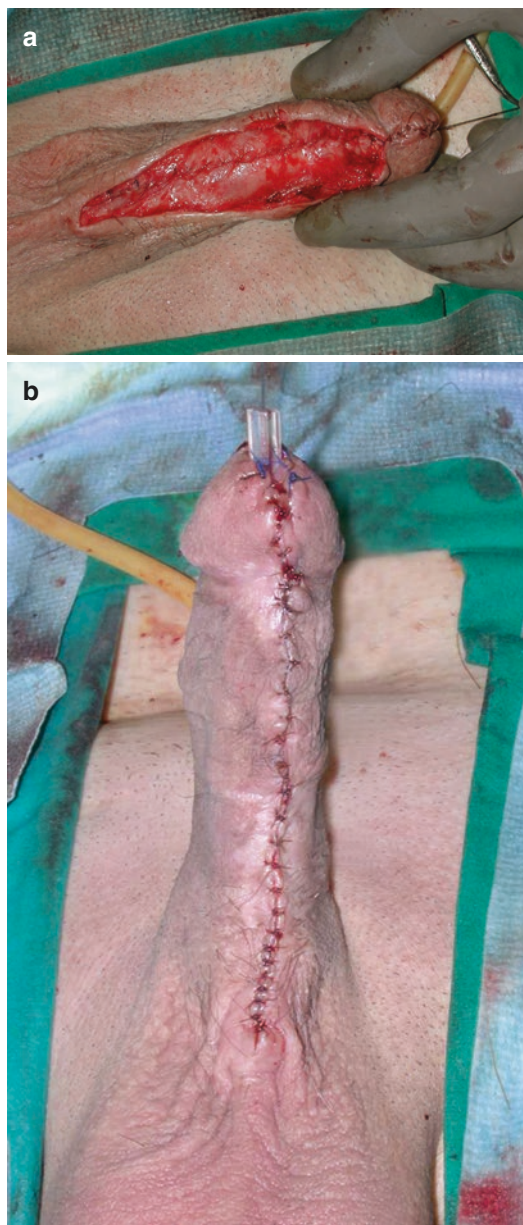


Fig. 11.11 (a) Layered urethral and glans closure; (b) Final skin closure and urethral stent

horizontal mattress sutures of 4-0 or 5-0 Vicryl. A Foley catheter (typically 16 French) or a stent along with a suprapubic catheter for urinary diversion may be used at the discretion of the surgeon. The urethral catheter or stent is removed approximately 3 weeks after surgery. Voiding cystourethrogram is obtained at that time in select patients depending on the characteristics of the case. Patients are subsequently allowed to gradually resume activities, however we ask them to avoid sexual intercourse until 8 weeks postoperatively.

11.5 Discussion

Bengt Johanson popularized staged urethroplasty in the 1950s, although it was first described nearly 40 years prior by Russell [6, 12]. The Johanson repair utilized perineal or genital skin in a staged approach. With this procedure, there was not always sufficient skin to provide for an adequate caliber urethra and subsequent coverage ventrally. In addition, it was found that scrotal skin tended to cause issues with hair growth in the neourethra, diverticulum, and stricture recurrence related to urine-induced dermatitis. Schreiter described mesh-graft urethroplasty in 1984, during which additional skin was added to the ventrum of the penis prior to tubularization [13]. Schreiter and Noll later published their experience with mesh graft urethroplasty in 96 patients using either foreskin or split thickness skin graft and only documented one failure [14]. Carr and colleagues published their experience with 20 patients who underwent mesh graft urethroplasty. Five men did not undergo the second stage procedure. Of the 15 patients who underwent two stage repair, 12 patients (80%) had a successful outcome as evidenced by review of symptoms and radiographic imaging at a median follow up of 38 months [4].

Bracka popularized the use of oral mucosa in staged hypospadias repair in the mid-1990s, and this tissue quickly eclipsed other forms of urethral augmentation or replacement due to its relative ease of harvest, durability, and compatibility with a moist environment [3]. Pfalzgraf,

et al. compared their series of staged urethroplasties using both meshed STSG and oral mucosa. Patient satisfaction was relatively high in both groups (oral mucosa graft 96.7% vs mesh graft 83.3%), however postoperative erectile dysfunction (4%) and penile curvature (9%) were only observed with mesh graft urethroplasty [11].

For complex penile urethral strictures where staged procedures are indicated, oral mucosa graft urethroplasty has been increasingly adopted over time. Kozinn et al. published their experience with 91 patients treated with staged procedures for urethral stricture. Stricture etiology was history of hypospadias or LS in the vast majority of cases. Strictures were panurethral in 55%, glans/distal penile in 30%, with the remainder being penobulbar and penile (8% each). All patients underwent staged oral mucosa graft repair. Over half (56%) of patients underwent subsequent urethral tubularization at a median of 15 months following the first-stage procedure. Interestingly, one quarter of patients did not progress to tubularization [7]. Figler et al. confirmed similar findings, with 40% of their cohort not proceeding to second stage urethroplasty at a median of 18 months follow-up [5]. This underscores the point that some patients are satisfied with the improvement in their voiding symptoms after the first stage, or are sufficiently adapted to a proximal urethrostomy before tubularization, and decide not to proceed with the morbidity or risk associated with a second intervention. These findings point to the importance of full assessment of the patient's goals and what they are willing to endure for a terminal meatus prior to the first stage, when a simple urethrostomy may be sufficient and avoid unnecessary grafting.

Some authors report significant revision rates after the first stage procedure, usually related to graft contraction or LS requiring additional placement of tissue prior to tubularization. Andrich et al. found that approximately 50% of patients required an additional procedure, with penile urethroplasty representing the majority of cases needing revision. While the authors found that the re-stricture rate was significantly lower as compared to single stage penile urethral recon-

struction (18% vs 4%), this came at the cost of an increased number of revision procedures particularly in patients with LS and failed hypospadias repair [1]. Kozinn et al. reported an 8% rate of additional revision surgery for those who ultimately progressed to tubularization. Reconstruction was deemed successful in 90% of cases, with only 9 patients requiring urethral dilation or chronic indwelling catheter at a mean follow-up of 15 months [7]. Mori et al. reported similar success rates in 78 patients who underwent staged urethral reconstruction for complex anterior urethral strictures using oral mucosa. In this patient cohort over 94% of patients progressed to tubularization, and 14.1% needed more than two procedures (10.3% for revision and 3.8% for recurrent stricture). This relatively low rate of revisional surgery was related in part to the use of additional oral mucosa to augment the urethral plate at the time of second stage tubularization [9]. Spilotros and colleagues found that penile and penobulbar urethral strictures had a significantly higher re-stricture rate compared to bulbar strictures after definitive repair (25.8% vs 12.1%, $p < 0.05$). The penile and penobulbar strictures were repaired in a staged fashion in nearly all cases (61/62), while the bulbar strictures underwent primarily single stage repair (62/64) [15]. In a more recent series, Figler et al. noted the most common complications after second stage urethroplasty were wound dehiscence (17%), meatal stenosis (8%) and fistula (8%) [5].

As alluded earlier, stricture etiology has been shown to correlate with treatment success. Strictures associated with LS had higher revision rates, mostly after the first stage due to either graft contracture or LS recurrence involving the graft. The high revision rate in patients with LS reinforced the importance of staged procedures over single stage urethroplasty in this patient population. Patients with a history of hypospadias and no evidence of LS had a higher overall success rate of 97.5% [7]. Additional studies of patients undergoing staged buccal graft urethroplasty for penile urethral strictures arising after prior surgery for hypospadias have demonstrated success rates of 82–86% [2, 8]. These findings further under-

score the need for individualized preoperative counseling in these complex cases.

Emerging data shows that sexual function can be impacted with staged urethroplasty. Patel and collaborators assessed patient reported sexual function in 33 patients using validated questionnaires in a multicenter cohort. Eighty-two percent had either improved or unchanged satisfaction with sexual intercourse, and 90% reported reduced or no change in bother with ejaculation postoperatively. The most common self-reported issues after staged urethroplasty were loss of penile length (55%), altered penile sensitivity (45%), and new onset penile curvature (23%) [10]. In another study, 8 of 62 patients (13%) who underwent penile or penobulbar staged urethroplasty complained of erectile dysfunction over a year out from their final repair. Interestingly, all these patients had a good response to PDE5 inhibitors [15].

11.6 Conclusion

Staged urethroplasty for penile urethral stricture remains an important option for patients with extensive lichen sclerosis, history of failed hypospadias repair, obliterative strictures, and previous failed urethral reconstruction. Preoperative evaluation is critical in this difficult patient population for appropriate surgical planning and patient counseling. Postoperative success rates have improved over time with advancements in technique and understanding of the pathophysiology of urethral stricture disease, and now range from 80% to 90% in most published series. Therefore, in well selected patients, staged urethroplasty for penile urethral strictures represents a technically feasible repair with robust outcomes. Nonetheless, some patients will require more than two surgical procedures to complete the reconstruction. There will also be occasional patients who will opt to not proceed with second stage tubularization due to satisfaction with voiding through a proximal urethrostomy. It is important to try to identify such patients preoperatively in order to simplify their surgical management.

Key Summary Points

- Staged urethroplasty is a reliable procedure for difficult penile urethral strictures not amenable to one-stage graft or flap reconstruction.
- Indications for staged urethroplasty include strictures and/or fistulas associated with lichen sclerosis, obliterated urethra, or those occurring after previous surgery for hypospadias.
- Buccal mucosa has emerged as the optimal graft for first stage augmentation of the ventral penis and urethral plate in order to provide sufficient tissue for subsequent urethral tubularization and coverage.
- More than two procedures may be required to complete staged penile urethral reconstruction due to a possible need for revisional surgery after the first stage for graft contraction or involvement by LS.
- In select cases it may be possible to complete a higher percentage of repairs in two operations using additional oral mucosa at the time of second stage tubularization.
- In order to avoid unnecessary procedures and graft harvest, careful preoperative evaluation and assessment of patient goals is critical to identify patients who may be content voiding through a proximal urethrostomy.

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Predictors of Urethral Stricture Recurrence After Urethroplasty

12

Soo Woong Kim and Hyun Hwan Sung

Urethroplasty remains the gold standard for the management of urethral stricture offering the highest success rates and in some instances the most cost-effectiveness compared to repeat direct vision internal urethrotomy (DVIU) or dilation. Although urethroplasty is considered a highly successful and durable treatment, one must remain vigilant for stricture recurrences which can occur many years after surgery. However, the factors that lead to urethroplasty failure are poorly understood. In this chapter, we would like to discuss about the predictors of stricture recurrence after urethroplasty.

12.1 Urethral Stricture Recurrence Rates

Although the modality for recurrence surveillance after urethroplasty remains widely variable, lifetime success rates range from 75% to 100% [1]. Many studies are heterogeneous with variable stricture location, length, etiology, and reconstructive

techniques. Given this variability, it is hard to compare studies, techniques, and outcomes. Also, it is hard to draw meaningful conclusion about the predictors of stricture recurrence after urethroplasty from the existing literature.

12.2 Common Predictors of Stricture Recurrences

Traditionally, common predictors for stricture recurrence include stricture location, length, prior DVIU or urethroplasty, age and so on. These predictors can be categorized as stricture-related, patient and operator factors (Table 12.1).

12.2.1 Stricture-Related Factors

12.2.1.1 Stricture Location

Urethroplasty for penile urethral stricture, often because of poor tissue quality, is technically more challenging than bulbar urethral surgery and the results have been reported to be less satisfactory [2]. Meeks et al. [1] conducted a systematic review of 302 articles publications from 2000 to 2008 which included 5617 urethroplasties to identify stricture recurrence rate after urethroplasty. They identified that penile stricture had a higher rate of recurrence (18.4%) compared to bulbar stricture (13.9%). To evaluate the learning curve of urethroplasty, Faris et al. [3] analyzed

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Table 12.1 Common predictors of urethral stricture recurrence after urethroplasty

Stricture-related factors
Stricture location
Stricture length
Prior DVIU
Lichen sclerosis
Patient-related factors
Age
Smoking
Comorbidities (obesity, diabetes mellitus, hypogonadism)
Surgeon-related factors
Surgeon experience
Selection of appropriate surgical procedure
Surgical learning curve

613 urethroplasty cases from six surgeons. The success for bulbar urethroplasty was higher than for penile urethroplasties (88.2% vs. 78.3%). There was a statistically significant trend toward improved outcomes with increasing number of cases, which was most pronounced with bulbar repairs. There was no statistical improvement in penile repairs over time.

12.2.1.2 Stricture Length

Previous studies have reported stricture length greater than 4 cm to be a risk factor for surgical failure [4, 5]. In a systematic review by Meeks et al. [1], the recurrence rate was significantly higher for longer strictures (≥ 5 cm, 16.6%) compared to that for shorter strictures (< 5 cm, 12.4%). Kinnaird et al. [6] conducted a retrospective review of 604 urethroplasties to determine the risk factors for stricture recurrence. Strictures of ≥ 5 cm were found to increase recurrence from 6% to 14%. In a small series with 40 patients, the success rate is significantly lower in strictures longer than 7 cm (stricture-free rate; 88% vs. 40% at 43.4 months follow-up) and panurethral strictures [7].

12.2.1.3 Prior DVIU

Many nationwide surveys regarding practice patterns of urethral stricture showed similar results that most urologists had little experience with urethroplasty while DVIU or dilation were often performed despite of limited success rate

[8–11]. However, repeated DVIU can increase the length and density of spongiofibrosis, thus making definitive surgical intervention more difficult [12]. Clinical guidelines state that the indication for DVIU/dilation as first line therapy should be limited to strictures with favorable characteristics and repeated DVIU/dilation should be avoided because of low efficacy and increasing spongiofibrosis [13, 14]. Especially, a third DVIU/dilation is not recommended, except if necessitated by patient comorbidities or economic resources [13].

Greenwell et al. [15] reported that repeat DVIU or dilation for the treatment of urethral stricture is neither clinically effective nor cost-effective. Many other studies also demonstrated that repeat transurethral manipulation is associated with increased stricture complexity and recurrence rate [4, 11, 16, 17]. Hudak et al. [17] divided 101 cases with bulbar urethral stricture into 2 groups based on the history of transurethral treatment before urethroplasty; group 1-0 or 1 and group 2-2 or greater treatments. The authors concluded that repeat transurethral manipulation of bulbar strictures is associated with increased stricture complexity and a marked delay (eight-fold) to curative urethroplasty.

12.2.1.4 Lichen Sclerosis

Strictures due to lichen sclerosis most primarily affect the penile urethra and tend to be longer. Concerning lichen sclerosis, the success rate of urethral repair is significantly lower for patients with the skin disease than without the inflammatory condition. Erickson et al. [18] analyzed data from 1151 men who underwent urethroplasty from their multi-institutional database. Patients with lichen sclerosis had average longer strictures, mostly involving the penile urethra and rarely the bulbar urethra alone. Substitution urethroplasty had a significantly lower success rate than strictures due to other causes (82% vs. 92%). In addition, a significantly higher rate of chronic, systemic inflammatory conditions, such as hypertension, diabetes, and obesity, was noted in the lichen sclerosis patients compared with patients without the condition.

12.2.2 Patient Factors

12.2.2.1 Age

Elderly men commonly undergo urethral instrumentation and transurethral treatment of benign prostatic hyperplasia. Consequently, the incidence of urethral stricture is greatest in the aging population [19]. On multivariate analysis of 443 patients who underwent urethroplasty, age (older than 65 years) was not predictive of surgical failure [4]. To determine if age is an independent predictor of surgical success in patients undergoing urethroplasty, study outcomes were compared between 2 age groups (<60 years old and ≥ 60 years old) [20]. Of 322 urethroplasties, 258 were performed in patients <60 years and 64 in patients ≥ 60 years. There was no difference in need for repeat procedures or anatomic recurrence between age groups or with increasing age. Recently, Viers et al. [21] reported the largest single-institution series to evaluate surgical outcomes of urethroplasty in aging men. Among 514 urethroplasty procedures, 184 (36%) were evaluated in men ≥ 60 years. The estimated 60-month stricture recurrence-free survival decreased with increasing age at time of urethroplasty. Of course, age alone should not be used as a contraindication to urethroplasty, however, it should be noted that comorbidities are common in aging men [20, 21]. In addition, it should be kept in mind that voiding dysfunction and prostatic obstruction are common in this population.

12.2.2.2 Smoking

Current smoking predicted increased risk of stricture recurrence on multivariate analysis of 443 patients (hazard ratio 1.8) [4]. However, smoking was not associated with recurrence in other studies [6, 20, 22].

12.2.2.3 Comorbidities

Obesity

Obesity is a global epidemic. Obesity is associated with an impaired immune response, which likely contributes to the increased rate of surgical site infection, a well-known cause for surgical

failure of urethroplasty [23, 24]. In addition, obesity patients often have comorbidities such as cardiovascular disease that also can affect surgical outcomes [24]. In a retrospective review of 15 obese men with body mass index (BMI) >35 mg/m², obese men demonstrated poorer outcomes after grafted bulbar urethroplasty when compared with published success rates in the general population as well as an aged-matched, nonobese cohort from authors' institution [25]. Similarly, on multivariate analysis of 596 patients who underwent bulbar urethroplasty, obesity (BMI ≥ 35 mg/m²) was associated with stricture recurrence (hazard ratio 2.9) [22]. Breyer et al. [26] demonstrated that patients who are overweight (BMI 25–30 kg/m²) and obese (BMI 30–35 kg/m²) develop urethroplasty failure more frequently, however, the severely and morbidly obese did not. The authors hypothesize that this non-linear relationship between BMI may relate to the more sedentary status of the morbidly obese patient and that this protects against activities that may put their urethroplasty at risk of failure ('obesity paradox') [27]. In a recent retrospective review of 137 patients, BMI did not independently predict for stricture recurrence following urethroplasty [28].

Diabetes mellitus

On multivariate analysis of 381 patients who underwent urethroplasty and had complete BMI data, diabetes mellitus was a significant negative influence on urethroplasty outcome [26]. In another review by Breyer et al. of 443 patients, diabetes was associated with an increased risk of stricture recurrence (hazard ratio 2.0), though it was not statistically significant [4]. In this study, diabetes appears to be under reported. Diabetes is known to cause microvascular damage which could impede healing after urethroplasty and promote stricture recurrence. However, research on this subject is very limited.

Hypogonadism

Recently, Spencer et al. [29] reported that hypogonadism is more prevalent and associated with increased disease severity in men with urethral stricture. Age, diabetes and obesity, potential predictors for stricture recurrence, are also associated

with hypogonadism [30]. Therefore, further studies are needed on this subject.

12.2.3 Operator Factors

In fact, the ability of the operator might be the most important factor to determine the success rate of the urethroplasty. In a retrospective review of 90 patients with penile stricture undergoing 109 open urethroplasties, there was a significant decrease in failure rate when comparing the first consecutive 55 cases to the last 54 cases [31]. The authors suggested that surgeon’s experience and probably the selection of an appropriate method seem to be paramount importance for success of urethroplasty. A total of 613 urethroplasty cases from six surgeons were analyzed [3]. Overall success rates improved significantly with time (surgeon experience), and proficiency (defined as >90% success) occurs after approximately 100 cases. In a single-surgeon (Guido Barbagli) analysis of 641 patients treated with one-stage urethroplasty, surgeon experience was significantly associated with a lower probability of treatment failure (hazard ratio per 20 procedures: 0.98) [32]. The surgical learning curve appeared lengthened, without reaching a plateau even after 600 procedures.

12.3 Predictors of Stricture Recurrence for Each Procedure

The management of urethral stricture disease in adult males has a wide range of possible therapeutic options. These predictors can be determined according to anatomic location and type of urethroplasty (Table 12.2).

12.3.1 Bulbar Urethral Stricture

12.3.1.1 Excision and Primary Anastomosis

Stricture Length

For short bulbar urethral stricture, excision and excision and primary anastomosis (EPA) remains the ideal procedure with excellent long-term

Table 12.2 Predictors of stricture recurrence for each urethroplasty procedure

<i>Bulbar urethral stricture</i>	
Excision and primary anastomosis (EPA)	
Stricture length (>2 cm) [34–36]	
Prior treatments (multiple dilations, DVIU or urethroplasty) [3]	
Substitution urethroplasty	
Ventral onlay urethroplasty	
Qmax <7 ml/s [41]	
Dorsal onlay urethroplasty (no data found)	
Two-sided onlay urethroplasty	
Stricture length (≥4 cm) [43]	
Augmented anastomotic urethroplasty	
Age (older patients) [45]	
Urinary tract infection [45]	
Stricture length [46]	
<i>Penile urethral stricture</i>	
Substitution urethroplasty	
Dorsal inlay urethroplasty (Asopa technique) (no data found)	
One-sided dorsolateral onlay urethroplasty (Kulkarni technique) (no data found)	
Flap urethroplasty	
Penile circular fasciocutaneous (McAninch technique) – onlay variant	
Previous hypospadias repair [54]	
Smoking [54]	
Stricture length (>7 cm) [54]	
Pen. circ. fasciocut. (McAninch technique) – tubed variant (no data found)	
<i>Urethroplasty after PFUI</i>	
Type of fracture (vertically unstable and/or rotationally unstable)	
Displacement of inferior medial pubic bone	
Symphysis pubic diastasis	
Timing of management (early endoscopic realignment/open recons.)	
Severity of injury (defect length and type)	
Prior therapeutic history (revisional surgery and repeated DVIUs)	
Incomplete excision of scar tissue during surgery	
Surgical competence (≥10–15 cases/year) [79, 80]	

results. A total of 17 level 3 evidence series with >10 patients were included for analysis, and the composite success rate reported among 1234 men having EPA for bulbar urethral strictures was 93.8% [33]. In general, the best stricture length manageable by EPA is 2 cm or less, however, strictures longer than 2 cm can be managed successfully in selected patients with EPA [34–36]. Morey and Kizer [37] reported on a selected cohort of 22 patients with proximal bulbar ure-

thral strictures longer than 2.5 cm that were treated with an extended anastomotic approach and suggested that the ability of the urethra to be reconstructed is proportional to the length and elasticity of the distal urethral segment.

Previous Treatment

The impact of previous treatment on surgical outcomes is controversial. In 2 large series of EPA reported by Santucci et al. [34] and Eltahawy et al. [35], 55% and 69.2% of patients had a history of failed attempts of urethroplasty or DVIU, respectively, and despite this, surgical outcomes were equally excellent. By contrast, in the study by Barbagli et al. [36], the only group of patients who had a lower success rate (78.6%) had undergone multiple treatments (dilation, DVIU, or urethroplasty), whereas the other groups (prior single or no treatment) showed similar success rates ranging from 92.1% to 100% without any statistical significance.

Stricture Etiology

There is no clear consensus on stricture etiology and the success rate with respect to EPA. However, it is generally accepted that traumatic stricture due to perineal straddle injury is best treated by EPA. Suh et al. [38] reported that the recurrence rate was significantly higher in patients with nontraumatic causes (26.7%) than in the patients with traumatic cause (0%). The authors suggested that the most likely reason for the better results in the traumatic group is that spongiofibrosis developed from outside to inside, which makes it easier to identify the extent of stricture. On the contrary, spongiofibrosis propagated from inside to outside in urethral strictures of nontraumatic causes, especially those with iatrogenic or infectious causes. Therefore, the surgeon should convert an EPA to augmented anastomotic urethroplasty without hesitation if there is any concern about inadequate excision of unhealthy tissue.

12.3.1.2 Substitution Urethroplasty

Ventral and dorsal onlay urethroplasties are the most popular types of substitution urethroplasty. In a meta-analysis, buccal mucosa graft (BMG) had the highest success rate (88.1%) and the success rate was similar between the ventral and dor-

sal onlay techniques (87.6% vs. 89.2%) [39]. In a systematic review, there was no difference in the success rate of a ventral and dorsal onlay technique for the bulbar stricture (88.8% vs. 88.4%) [40]. However, ventral onlay urethroplasty is usually carried out only for midbulbar and proximal bulbar stricture, where the thick spongiosum provides excellent blood support for the graft. In addition, most reconstructive surgeons prefer dorsal onlay BMG instead of ventral BMG urethroplasty if there is significant spongiofibrosis. Therefore, comparisons of surgical outcomes between ventral and dorsal BMG onlay urethroplasty are limited by selection bias.

Ventral Onlay Urethroplasty

In a retrospective study of 214 patients who underwent ventral onlay urethroplasty with BMG for bulbar urethral stricture, the success rate was 85.5% with median follow-up of 54 months [41]. The preoperative maximum flow rate (Q_{max}) was a significant predictor of surgical outcome. Patients with a preoperative Q_{max} 7 ml/s have more than a threefold higher success rate compared with patients with a preoperative Q_{max} <7 ml/s. However, age, length, and type of stenosis, and previous treatment were not significant predictors of surgical outcome.

Dorsal Onlay Urethroplasty

Barbagli et al. [42] reported the 80.2% long-term success rate in 81 patients for dorsal onlay bulbar urethroplasty using BMG. A total of 359 patients who underwent substitution urethroplasty were included in study. Substitute tissue type (oral mucosa vs skin) was the only significant predictor on multivariate analysis.

Two-Sided Onlay Urethroplasty (Palminteri Technique)

In a single-center retrospective study of 166 patients who underwent 2-sided dorsal plus ventral BMG urethroplasty by preserving the narrow urethral plate in tight bulbar strictures, success rate was 89.8% with a median follow-up of 47 months [43]. The stricture length (≥ 4 cm) was a significant predictor of stricture recurrence; however, age, stricture etiology, and previous treatment were not significant predictors of surgical outcome.

12.3.1.3 Augmented Anastomotic Urethroplasty

Guralnick and Webster [44] introduced the term ‘augmented anastomotic urethroplasty (AAU)’ to describe a hybrid procedure combining elements of the EPA and substitution urethroplasty. Abouassaly and Angermeier [45] reported their experience of AAU in 69 patients with a success rate of 90% at a mean follow-up of 34 months. In 58 patients (84%) the graft was placed ventrally, whereas in 11 (16%) it was placed in the dorsal position. They found that recurrence tended to occur in older patients and in those with postoperative urinary tract infection. Hoy et al. [46] reported the results of 163 patients who underwent dorsal onlay AAU with BMG. The success rate was 96.9% with a median follow-up of 31 months. They suggested that strictures longer than 5 cm are amenable to repair using this technique, but are prone to recurrence. El-Kassaby et al. [47] reported the largest series using AAU with ventral BMG onlay. The success rate was 93.7% in 233 patients with a mean follow-up of 36 months. There was no comment on potential risk factors for recurrence.

12.3.2 Penile Urethral Stricture

12.3.2.1 Substitution Urethroplasty

Dorsal Inlay Urethroplasty (Asopa Technique)

There have been limited data about the surgical outcomes of Asopa’s ventral sagittal urethrotomy and dorsal inlay urethroplasty [48, 49]. The main advantage of the Asopa technique is that it is easy to perform and has no need to urethral mobilization. The main drawback is that the augmentation of the Asopa technique is less wide than that can be achieved with the dorsal onlay technique. Additionally, it is best to perform this technique when the urethral plate is not too narrow (≥ 1 cm in width) [50].

One-Sided Dorsolateral Only Urethroplasty (Kulkarni Technique)

Kulkarni et al. [51] developed a new one-sided anterior dorsal BMG urethroplasty while preserving the lateral vascular supply to the urethra.

Kulkarni et al. [52] presented their experience with this technique in 117 patients with panurethral stricture. The overall success rate was 83.7% with a success rate of 86.5% for primary urethroplasty and 61.5% in patients in whom urethroplasty had previously failed.

12.3.2.2 Flap Urethroplasty

Ventrally placed circular penile fasciocutaneous flap described by McAninch is likely to be the most useful technique, with excellent cosmetic and functional results [53]. The benefits of this procedure include its hairless nature, sufficient length (13–15 cm), flexibility, and versatility [54]. However, it should be used as an onlay rather than tubularized flap because of high risk for restenosis [14]. For urethral stricture secondary to lichen sclerosus, genital skin should not be used when reconstruction is performed [14]. Whitson et al. [54] reported the long-term efficacy of distal penile circular fasciocutaneous flap for single-stage urethroplasty in 124 patients with complex anterior urethral strictures. At 1, 3, 5, and 10 years, the overall estimated stricture-free survival rates were 95%, 89%, 84%, and 79%, respectively. On multivariate analysis smoking (hazard ratio 4.0), history of hypospadias repair (hazard ratio 4.4) and stricture length 7–10 cm (hazard ratio 7.0) were predictive of failure.

12.4 Urethroplasty for Pelvic Fracture Urethral Injuries

Basically, the term urethral stricture refers to anterior urethral disease by consensus of the World Health Organization conference [55]. In contrast, posterior urethral ‘strictures’ are not included in the common definition of urethral stricture. Pelvic fracture urethral injuries (PFUI) are injuries to the urethra that result from disruption of the pelvic ring. The term ‘pelvic fracture urethral distraction defect’ has therefore been discontinued and replaced by PFUI, because a large percentage will be partial injuries and even complete ruptures will not always present as a separation of the urethral ends [56]. Subsequent narrowings of the posterior urethra are termed as urethral stenosis.

12.4.1 Issues of Immediate Management

One of the most debatable issues in the treatment of PFUI patients is whether to perform endoscopic primary realignment or delayed urethroplasty after suprapubic cystostomy. Most surgeons favor the delayed reconstruction because urethral stenosis or complete obliteration of lumen is almost inevitable after primary realignment, and primary realignment may lead to additional urethral trauma, even may worsen the prognosis after delayed urethroplasty [57–59]. Singh et al. [60] reported that endoscopic primary realignment or immediate primary urethroplasty significantly decrease the success of subsequent anastomotic urethroplasty. Tausch et al. [61] also reported that compared to delayed urethroplasty, primary realignment often appears to be associated with a complex and prolonged treatment course for men with PFUI. Primary realignment was not associated with shorter strictures or easier urethroplasty, and it is reported to have prolonged clinical course and time to urethroplasty [59, 62]. On the other hand, it has been also suggested that primary realignment may reduce risk of subsequent urethral stenosis and obliteration. Primary realignment may also obviate the need for urethroplasty in some cases and does not increase complications rates [62–64]. Recent systematic review demonstrated that about half of the patients were free of stenosis or obliteration and thus did not undergo urethroplasty in case primary realignment had been performed [64]. However, they also commented that this study was limited by a high degree of bias due to the heterogeneous population.

The main problems about these issues have been the lack of any randomized studies with comparable groups of patients in comparable situations and the lack of a defined outcome or endpoint [56, 64]. In practice it is clear that primary realignment is usually reserved for those with less serious injuries. Currently, ongoing prospective multi-institutional cohort study would determine the utility of primary realignment after PFUI [65]. The AUA guideline in the urotrauma section summarized that clinicians

Table 12.3 Main indications for immediate open repair

Penetrating injuries
Bladder neck and prostate injuries with perineal degloving
Associated rectal injury

may perform primary realignment in hemodynamically stable patients with PFUI, but prolonged attempts must be avoided as the process may increase injury severity and long-term sequelae [66]. Immediate open repair was associated with significant morbidity including the greater incontinence and impotence rates [56]. Currently, the main indications for immediate open repair are penetrating injuries, injuries of the bladder neck and prostate, injuries associated with perineal degloving and injuries associated with a rectal injury (Table 12.3) [58].

12.4.2 Imaging Modalities Predicting Type of Surgery

Conventional retrograde urethrography might not predict the type of repair, mainly because the bladder neck and prostatic urethra are not always visualized [67]. Andrich et al. [67] concluded that a surgeon treating PFUI should be competent and prepare all steps of repair, because any of them could be required. Koraitim et al. [68] suggested that the gapometry/urethrometry index defined as the ratio of the length of the gap between the 2 ends and the measured length of the bulbar urethra, could predict the type of surgery, simple versus elaborated or transpubic approach. The role of magnetic resonance imaging (MRI) is adjunct to retrograde urethrography and limited particularly when associated pathology is strongly suspected in the setting of PFUI. Horiguchi et al. [69] recently reported that pubo-urethral stump angle defined as the angle between the long axis of the pubis and the line between the distal end of the proximal urethral stump and the lower border of the inferior pubic ramus using MRI, is useful for predicting the type of reconstruction needed for urethral repair. They concluded that low pubo-urethral stump angle was an independent predictor of a need for an elaborate approach.

12.4.3 Timing of Urethroplasty

The ideal timing of urethroplasty after injury is unknown. The current standard is 3–6 months from the time of injury, although it sometimes takes more than 6 months to manifest itself [70]. If performed earlier, the tissues are often still insufficiently recovered to be able to hold sutures, and then the best outcome cannot be achieved [58]. Meanwhile, Scarberry et al. [71] recently reported similar outcomes following urethroplasty for PFUI patients repaired less than 6 weeks after injury compared with those delayed more than 12 weeks. They concluded that in selected cases urethroplasty at 3–6 weeks is feasible, minimizing the morbidity of suprapubic cystostomy. The safety and efficacy of earlier repair protocols (3–4 weeks) needs to be established.

12.4.4 Perioperative Predictors

The success of urethroplasty in patients with PFUI will be affected by multiple perioperative factors: the age of patient, the severity of injury (defect length and type of prostatic displacement), prior treatment history (revisional surgery and repeated endoscopic managements), incomplete excision of scar tissue during the surgery, and complicated by the coexistence of an ano-rectal injury, vaginal injury, and perineal degloving injury [61, 68, 72–75]. Koraitim and Kamel [72] reported that meticulous and complete excision of scar tissue is critically important to optimize the outcome, especially in cases with lateral prostatic displacement. Fu et al. [73] demonstrated that the length and position of defect and its distance to bladder neck plays the key role, and co-existed rectal injury is also an indicators of poor outcome. Bladder injury, urethral fistula, failed urethroplasty or repeated endoscopic management seems to have insignificant effect in their study. Singh et al. [60] reported that a previous realignment or urethroplasty may have a significant adverse effect on the outcomes of subsequent delayed urethroplasty [60].

12.4.5 Operator Factors

In competent hands and with uncomplicated PFUIs, the success rate of urethroplasty has been reported as 90–95% [76–78]. The success rate depends not only on the severity of the injury, but also on the surgical competence. Therefore, surgeons should prepare all steps of urethroplasty related to the steps necessary to achieve a tension-free anastomosis [56]. There is no evidence available to suggest how many times a surgeon should have performed index procedures before being regarded as competent, nor what the continuing caseload should be to maintain competence [79]. Andrich et al. [79, 80] suggested that at least 10–15 cases a year is necessary to maintain competence, it probably requires one surgeon, or surgical team, for every 10–15 million of population at least.

Key Summary Points

- Urethral stricture is a prevalent health problem with high socio-economic impact on national health budgets
- The most common etiologies of urethral strictures differ worldwide
- Urethroplasty is an excellent and cost-effective curative treatment for urethral strictures, especially those that have failed conservative endoscopic treatments, and remains the gold standard for longer, complex or recalcitrant strictures
- Most urethral recurrences occur early within the first 6 months
- Preoperatively identifiable factors, most likely due to impaired vascularity and deficient blood supply, are associated with an increased risk of recurrence.

Recognition of these preoperative factors allow for identification of patients at higher risk for failure before surgical planning, for whom a closer and more prolonged follow-up protocol should be recommended.

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Role of Non-transecting Anastomotic Urethroplasty for Bulbar Urethral Strictures

13

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13.1 Introduction

Every surgeon should attempt to reduce iatrogenic damage to surrounding structures and their vasculature during surgical intervention. Excision and primary anastomosis (EPA) is a well-established and frequently used type of urethroplasty in the repertoire of the reconstructive urologist to treat a urethral stricture. Transecting EPA (tEPA), the classic technique, encompasses full transection of the urethra and the surrounding spongy tissue containing the urethral vasculature at the site of the stricture. However, as the spongiositis surrounding the stricture rarely affects the whole thickness of the corpus spongiosum, the question arises whether it is necessary to perform this full thickness transection and its associated iatrogenic damage to the urethra's blood supply. For this reason, the concept of non-transecting anastomotic urethroplasty (NTAU) was introduced by Jordan et al. in 2007 [1] and further explored in the following decade. To understand the concept of NTAU, it is indis-

pensable to have a profound knowledge of the vascular anatomy of the male urethra. This will be highlighted in this chapter. This chapter will further discuss the indications and limitations of NTAU as well as the theoretic advantages of the technique. A detailed description of the technique and its variants will be provided. The surgical and functional results of currently available series will be summarized.

13.2 Anatomy of the Male Urethra with Special Attention to the Vasculature

The male urethra is subdivided in an anterior and posterior segment. The anterior urethra is further subdivided in the penile (or pendulous) urethra, from the external meatus to the penoscrotal junction, and the bulbar urethra, from the penoscrotal junction to the urogenital diaphragm. The posterior urethra contains the membranous urethra which lies in the urogenital diaphragm, the prostatic urethra surrounded by the prostate gland and the intramural part of the urethra (bladder neck) (Fig. 13.1).

The anterior urethra is surrounded by the corpus spongiosum. At the level of the penile urethra, the corpus spongiosum is relatively thin and the urethra runs centrally through it. This is in contrast to the bulbar area, where the urethra lies eccentric in the corpus spongiosum with abundant ventral spongy tissue. In the bulbar

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Fig. 13.1 Macroscopic anatomy of the male urethra. The anterior urethra contains the penile (a) and the bulbar (b) urethra. The posterior urethra contains the membranous urethra (c), the prostatic urethra (d) and the bladder neck (e). Transverse section through the bulbus where the urethra lies eccentric in the spongy tissue (1) and the penile part where it is located central in thin spongy tissue (2)

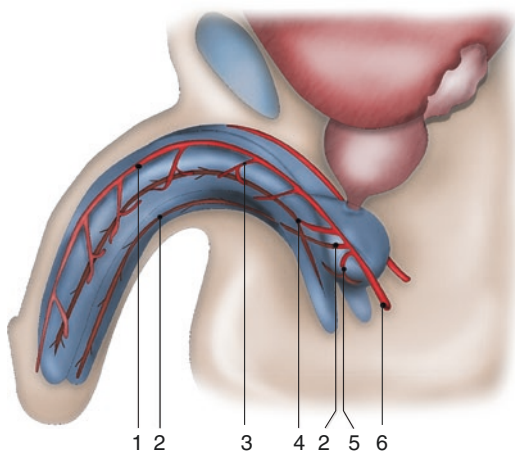
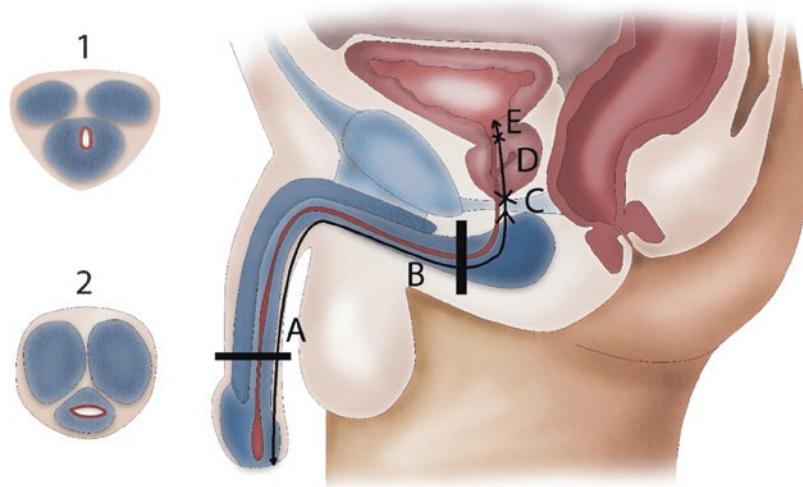


Fig. 13.2 Vascular anatomy of the penis and urethra: (1) dorsal penile artery (2) urethral artery (3) circumflex cavernosal artery (4) central cavernosal artery (5) bulbar artery (6) common penile artery

area, the corpus spongiosum is surrounded by the M. bulbospongiosus which is fixed to the urogenital diaphragm by the centrum tendineum or perineal body.

The vascular supply of the urethra is associated with the vascular supply of the corpus spongiosum (Fig. 13.2). This blood supply arises from the terminal branch of the internal pudendal artery, the common penile artery. The common penile artery then bifurcates into the central cavernosal artery, the dorsal penile artery and the bulbourethral artery. As an anatomical

variation, sometimes a separate bulbar and urethral artery arise from the common penile artery instead of the bulbourethral artery. The urethral artery runs longitudinally along the urethra at the four and eight o'clock position. Traditionally, a dual blood supply to the urethra has been described:

1. the bulbourethral (or bulbar and urethral) artery proximally penetrates the bulbus and is responsible for the antegrade urethrospungiosal blood flow.
2. the dorsal penile artery penetrates the glans penis and as the glans is the distal end of the corpus spongiosum, the dorsal penile artery is responsible for the retrograde urethrospungiosal blood flow.

In addition, there is a third vascularisation due to connecting vessels from the corpora cavernosa. Distal branches of the central cavernosal arteries also penetrate into the glans and add to the retrograde blood flow mentioned in 2. Furthermore, perforating arteries are present between the corpora cavernosa and corpus spongiosum. These perforating vessels are bilaterally present approximately every centimetre at the bulbar urethra. It is unclear whether these connections with the corpora cavernosa are important to the vascular supply during erection.

13.3 Indications and Limitations of NTAU

The different types of NTAU require mobilization of the urethra and will provoke some urethral shortening. Mobilization of the penile urethra followed by an anastomotic repair will lead to penile shortening and chordee. Therefore, NTAU is not indicated for penile strictures, not even short ones. The only exception is a patient who is already impotent and for whom penile length is not important. At the bulbar urethra mobilization between the penoscrotal angle and urogenital diaphragm will not affect the penile length. The bulbar urethra can be shortened somewhat thanks to two factors: the intrinsic elasticity of the urethra and straightening of the curve of the bulbar urethra [2]. The intrinsic elasticity of the bulbar urethra is about 25% and assuming an average bulbar urethral length of 10 cm [3], a gap of up to 2.5 cm can be bridged at the bulbar urethra.

Stricturoplasty based on the Heineke-Mikulicz principle (longitudinal incision, transverse closure) was first described by Lumen et al. in 2010 using a ventral approach [4]. The dorsal approach was first reported by Andrich et al. in 2012 [5]. This technique is only possible for very short strictures (≤ 1 cm), not too narrow and without substantial underlying spongiofibrosis [4, 6].

Indications for non-transecting excision and primary anastomosis (ntEPA) are the same as for tEPA: short (1–3 cm) bulbar strictures and membranous strictures. The decision to do an EPA (either transecting or non-transecting) is affected by the length of the bulbar urethra and the location of the stricture within the bulbar urethra. The general rule is: “the more proximal (to the prostate), the longer the stricture that can be treated by EPA”. Therefore, it is sometimes possible to treat a 3 cm deep bulbar stricture with EPA whereas it is not possible to treat a 1.5 cm bulbar stricture close to the penoscrotal angle. As a consequence, the classic stricture length limit of 2–2.5 cm is not strict and depends on the patient’s anatomy and stricture location. Because the stricture is removed and the urethra is replaced by its own healthy tissue, the results of EPA are among the best in urethral surgery [7]. The limit of EPA

is whenever a tension-free anastomosis can no longer be achieved. If the stricture has been opened and it is apparent that a tension-free anastomosis will not be possible, conversion towards substitution urethroplasty is needed. For ntEPA, where the urethra is opened at the dorsal side, a dorsal onlay procedure with a graft is usually performed. If the stricture has already been resected and after spatulation a tension-free anastomosis cannot be performed, a modified graft augmented end-to-end anastomosis can be performed (Augmented Non-Transecting Anastomosis <ANTA>). ANTA is also an option in case a dorsal onlay graft urethroplasty is performed but a short nearly obliterative segment is present.

Despite the optimal surgical results, some concerns arose with tEPA because of the reported effect of tEPA on the patient’s sexual function [8, 9]. As an alternative, some experts propose graft urethroplasty even for short bulbar strictures [10].

13.4 Possible Benefits of NTAU

In tEPA, the urethral artery is transected and this sacrifices the urethra’s antegrade blood supply. Furthermore, deep ventrolateral mobilisation during tEPA might also damage the bulbar arteries (or the bulbourethral artery). With ntEPA, the bulbar artery or bulbourethral artery is preserved as dissection at deep ventrolateral surface of the bulb is avoided. During ntEPA, it is attempted to preserve the urethral artery within the corpus spongiosum. However, in case of deep spongiofibrosis that also surrounds the urethral artery, the urethral artery needs to be sacrificed as well. Nevertheless, the ventral spongy tissue can be spared with continuous blood flow through the remaining spongy tissue. The circumferential mobilisation needed for both tEPA and ntEPA (but also for dorsal substitution urethroplasty) will damage the perforating arteries on both sides of the corpus spongiosum and this will have an effect on the urethra’s third blood supply. From a theoretical point of view, the more the blood supply towards the glans is disturbed, the greater the risk of vascular changes in the glans. Clinically,

this can be apparent as a cold feeling at the glans, alterations in glans sensitivity and/or a reduced tumescence of the glans during erection. These disturbances have been reported in respectively 1.6, 18.3 and 11.6% of cases after tEPA [11]. As the antegrade blood supply towards the glans is better preserved with NTAU, these alterations might be less frequent.

In the elderly and in patients with cardiovascular co-morbidity (esp. diabetes), a better preservation of the spongiosal blood supply might reduce the risk of subsequent ischemic spongiobrosis and late stricture formation after EPA. In this perspective, preservation of the bulbourethral artery should be beneficial. Furthermore, diabetes and its inherent microangiopathy delays normal wound healing at the anastomosis and spongy tissue, and is a risk factor of failure of urethroplasty [12]. Any factor that avoids further damage to the spongiosal blood supply, as provided by NTAU, might reduce this risk. In patients with hypospadias, the retrograde blood flow is absent and preservation of the antegrade blood flow should avoid ischemic changes in the distal urethra [13].

A better preservation of the spongiosal blood flow with NTAU might be advantageous in case of redo-urethroplasty as well. Approximately 10% of patients treated by EPA will suffer a recurrence (8). One of the options to treat this recurrence is ventral onlay free graft urethroplasty. A free graft urethroplasty is dependent on the vascularization of the graft bed (i.e. spongy tissue) and this might be better after NTAU compared to tEPA.

Preservation of the bulbourethral artery will cause less atrophy of the bulbus and the spongy tissue and there is less risk of erosion, in case an artificial sphincter or male suburethral sling is needed for urinary incontinence at a later stage (e.g. after radical prostatectomy) [1].

Knowing the vascular connections between the corpus spongiosum and the corpora cavernosa, it is possible that impaired spongiosal vascularization can have an effect on the blood supply of the corpora cavernosa. When the penis is in a flaccid state, this can cause ischemic changes in the cavernosal smooth muscle cells.

During erection, reduced blood supply and ischemic changes of the cavernosal smooth muscle cells might lead to diminished tumescence. With tEPA, a temporary decline in erectile function has been reported [14, 15]. Although this is most likely the consequence of damage to the cavernosal nerves during deep circumferential dissection, reduced cavernosal blood supply may add to this neurogenic etiology. As deep circumferential dissection is avoided with NTAU, the risk of neurogenic damage should be reduced as well.

It is important to stress that all the above-mentioned benefits are to date purely hypothetical and a direct benefit of NTAU compared to tEPA or other techniques of urethroplasty needs to be elucidated.

13.5 Surgical Description of Different Techniques of NTAU

The preoperative workflow is the same as for every urethroplasty. During history taking an emphasis must be placed on the stricture's etiology and previous urethral interventions. Clinical examination is important to evaluate the local genital anatomy, presence of a suprapubic catheter and old incision lines. The clinical suspicion of a urethral stricture must be confirmed by imaging, which should be performed at least three months after any urethral manipulation. After three months, the urethral tissue has been stabilized and the true extent of the stricture can be reliably delineated. The standard imaging technique is conventional urethrography which must show the presence of an isolated short bulbar stricture. A urine culture is performed approximately one week before the operation (especially important in patients with a suprapubic catheter) and antibiotics according to the antibiogram are started the day before the operation in case of urinary infection and maintained until catheter removal. If not, a prophylactic single dose 1 g cefazoline is administered at the start of the operation. Patients are placed in the low (distal to mid bulbar strictures) to standard (deep bulbar strictures) lithotomy position using supportive

boots. Nasal intubation must be performed in somewhat longer strictures where oral mucosa graft harvesting might be necessary. Although an inverted U or lambda incision is possible, we advise midline perineal incision as this is less painful for the patient. However, if a Blandy-type perineostomy is considered as escape option, an inverted U-incision is performed [16]. After subcutaneous dissection, the bulbospongiosus muscle is encountered and divided at the midline. The bulbospongiosus muscle is then dissected away from the urethra on both sides and a retractor is placed. This exposes the bulbar urethra. The bulbar urethra is circumferentially mobilized from the penoscrotal angle up to the urogenital diaphragm. It is important not to dissect distal from the penoscrotal angle as this will provoke penile shortening and/or chordee. Proximally, substantial mobilization of the bulbar urethra can be achieved by dividing the triangular ligament between the dorsal surface of the corpus spongiosum and the intercrural space. The proximal ventrolateral end of the urethra is not dissected. As a consequence, the perineal body remains attached to the bulbus and the bulbo-urethral arteries are not encountered [5, 17]. After full mobilization, a large size catheter (20 Fr) or metal sound is introduced in the urethra which delineates the distal end of the stricture. The stricture is opened at the dorsal side in a longitudinal fashion (Fig. 13.3).

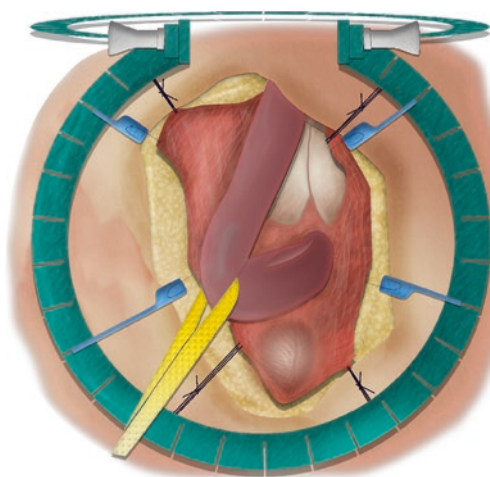


Fig. 13.3 Exposure of the bulbar urethra and dorsal stricturotomy

A 3 Fr ureteral catheter is passed through the stricture towards the bladder. This maneuver can also be performed using cystoscopy at the start of the procedure. The stricture is further longitudinally opened until healthy proximal urethral lumen is encountered. A 20 Fr catheter or metal sound is passed towards the bladder to verify patency of the urethra and to exclude a second more proximal stricture. Stay sutures are placed bilaterally at the proximal and distal end of the urethra to facilitate exposure of the stricture. At this point, different non-transecting techniques are possible depending on the degree of spongiositis, stricture location and stricture length (see paragraph indications):

1. Stricturoplasty (Heineke-Mikulicz principle)

The dorsal approach is now favored because a dorsal incision at the bulbar urethra is less traumatic and provokes less blood loss taking into account the dorsal eccentric location of the urethra within the bulbus. The principle is a longitudinal incision (Fig. 13.4a) of the stricture with a transverse closure. One absorbable 4-0 or 5-0 suture is placed in the middle and 1 or 2 additional sutures on each side (Fig. 13.4b, c). No excision of tissue is performed. If transverse closure around a 16 Fr urethral catheter is not possible, conversion to ntEPA or another technique is needed [4].

2. Non-transecting excision and primary anastomosis (ntEPA)

The scarred urethral mucosa with the underlying spongiositis is fully excised (Fig. 13.5a). This dissection must be deep enough and until healthy spongy tissue is encountered. In case the spongiosum is affected (nearly) completely, a conversion towards tEPA is possible without any difficulties. The proximal and distal end of dissection is delineated a few millimeters beyond the border of healthy versus scarred urethral mucosa. Both urethral ends are spatulated on the dorsal side for about 1 cm (Fig. 13.5b). The urethral plate (non-spatulated part on the ventral side) is anastomosed with four absorbable sutures

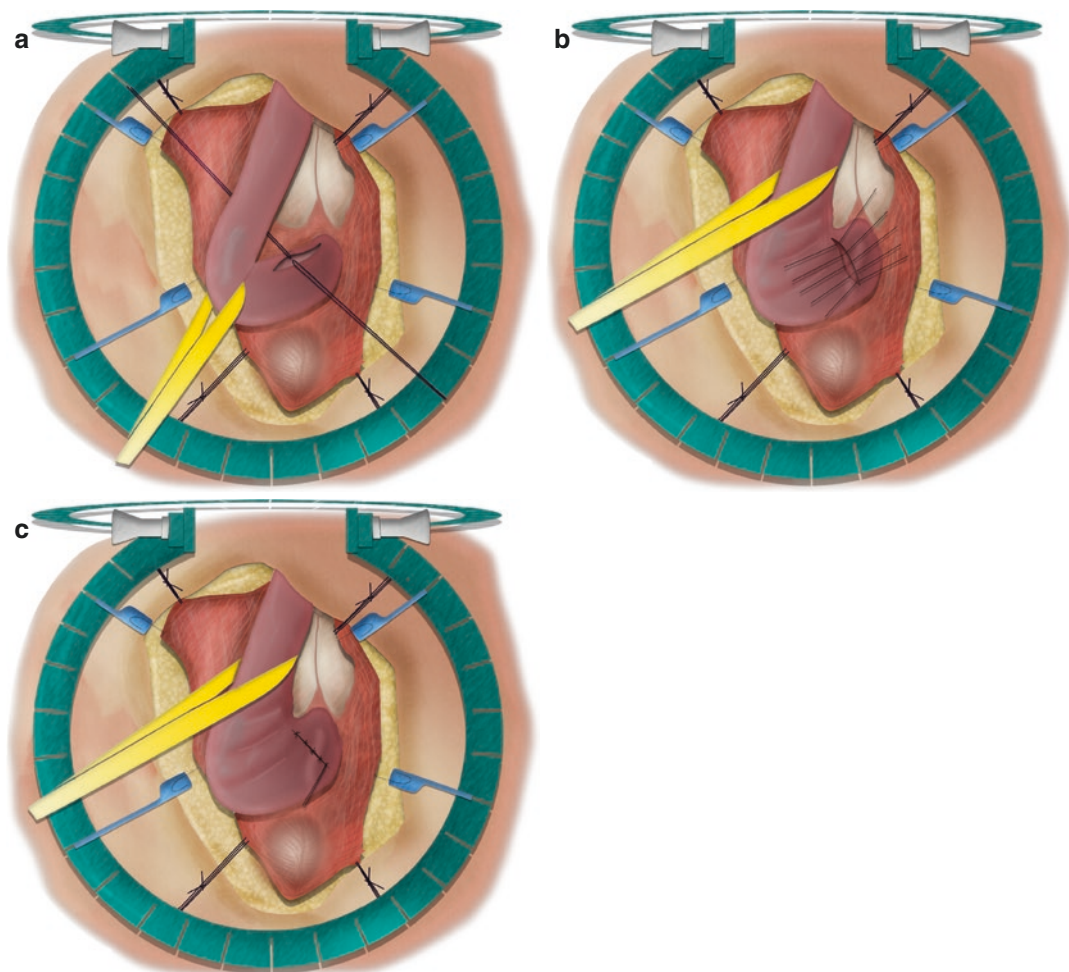


Fig. 13.4 (a) dorsal longitudinal incision with stay sutures to facilitate urethral mucosa exposure. (b) transverse closure with 1 central suture and 2 lateral sutures on

both sides. (c) Final result after transverse closure (last suture yet to be cut)

with the knot in the urethral lumen (Fig. 13.5c). The spatulated ends are sutured using the Heineke-Mikulicz principle: one absorbable suture in the middle (12 o' clock position) and two absorbable sutures with the knot on the outside on each side to finalize the anastomosis (Fig. 13.5d). The appropriate size of the sutures ranges from 4-0 to 6-0 [5, 17]. Finally, the dorsal spongy tissue is closed above the repair ("spongioplasty"; Fig. 13.5e). If a tension free anastomosis is not possible, conversion towards ANTA must be performed. The technique described above is slightly different compared to the initial technique developed by Jordan et al.

[1]. With his technique, the perineal body was dissected away from the bulbus and the bulbourethral arteries are identified and encircled with vessel loops during dissection. These maneuvers are not necessary and might even cause damage to the bulbourethral arteries. Therefore, it must not be performed [5].

3. Augmented non-transecting anastomosis (ANTA)

As described above, the scarred urethral mucosa and underlying spongiofibrosis are fully excised (Fig. 13.6a). Both dorsal urethral ends

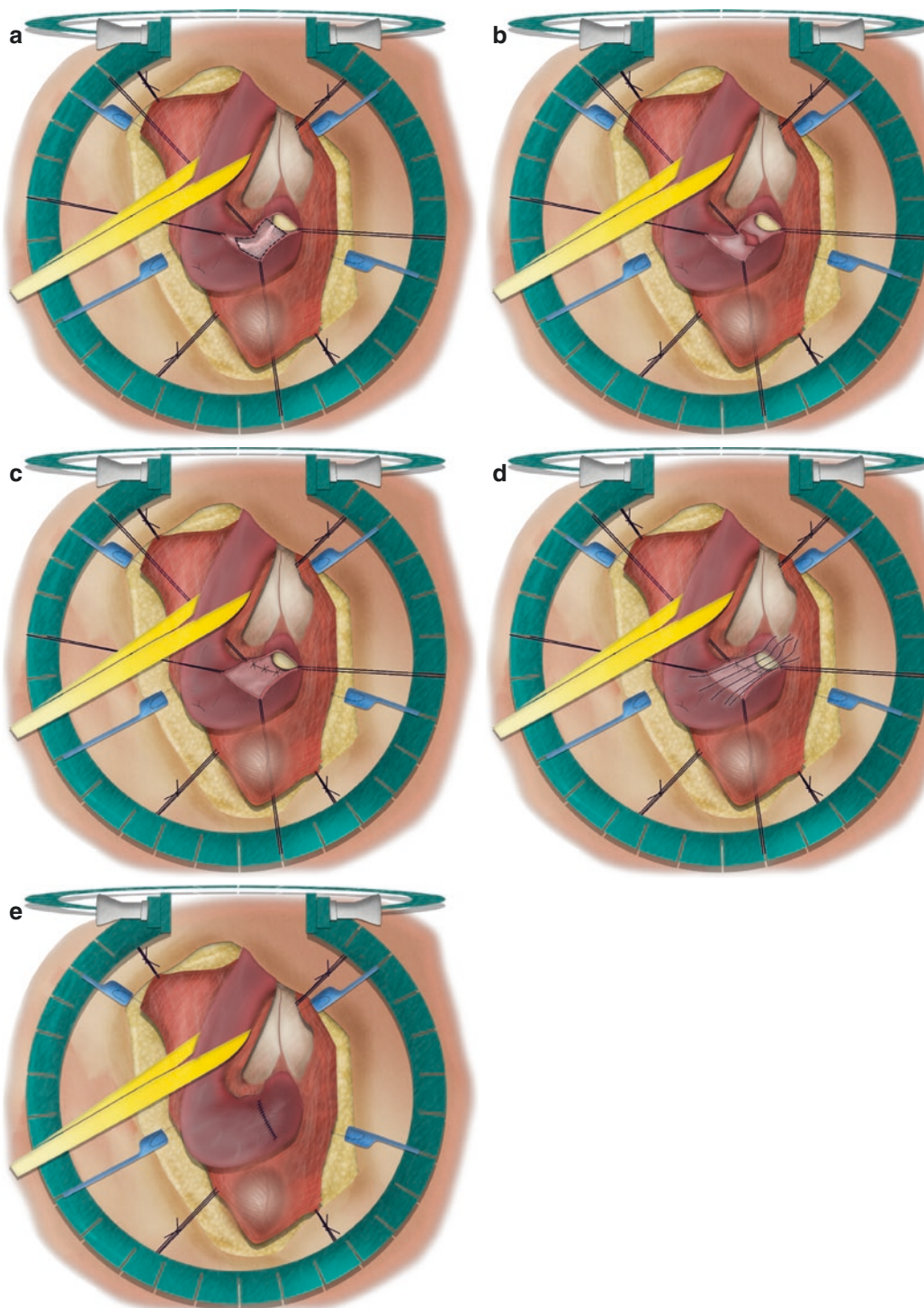


Fig. 13.5 (a) excision of the stricture and surrounding spongiositis by dorsal approach. (b) urethral spatulation on both dorsal urethral ends. A dorsal urethral defect exists after excision of the stricture and spongiositis. (c) reconstruction of the urethral plate. (d) reconstruction

of the dorsal urethra using the Heineke-Mikulicz principle. Five sutures are placed and the urethra is closed in a transverse fashion. (e) final result after transverse closure of the spongy tissue (spongioplasty)

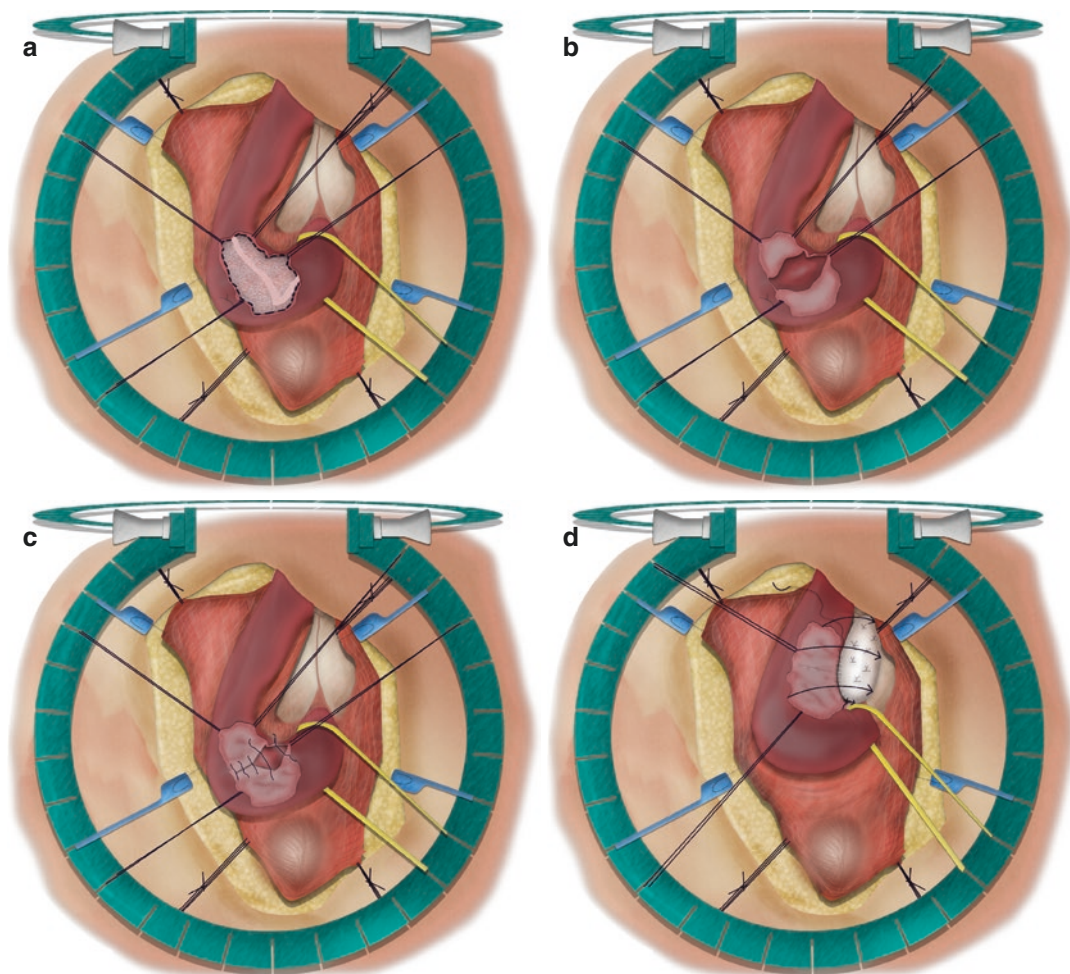


Fig. 13.6 (a) excision of (most narrow part of the) stricture and surrounding spongiositis. (b) spatulation of both urethral ends. A urethral defect exist after excision of (part of) the stricture. (c) reconstruction of the urethral plate. (d) a graft is sutured against the corporal bodies and

one side of the graft is sutured towards one side of the opened dorsal urethra. The urethra is thereafter turned over the graft and the opposite site of the graft is sutured to the other side of the urethra

are spatulated for about 1 cm (Fig. 13.6b). In case of a longer stricture, in which the use of a graft is certain, the most obliterated part of the urethra with underlying spongiositis is resected. The urethral plate is reconstructed as for ntEPA (Fig. 13.6c). The length and width of the dorsal urethral opening is measured and a graft is harvested according to the measured dimensions. The graft is defatted, meshed and quilted against the corporal bodies with absorbable 4-0 sutures. One side of the urethra is sutured to the graft with an absorbable 4-0 running suture. The urethra is

turned to its original position and the other side of the urethra is also sutured to the graft with an absorbable 4-0 running suture (Fig. 13.6d). During each step of the running suturing, the graft and urethra are attached to the underlying tunica albuginea of the corporal bodies. This is a further maneuver to fix the graft to its graft bed, limiting movements and thus promoting graft take. If the obliterative segment is too long for excision and anastomosis of the urethral plate, a classic dorsal only graft urethroplasty can be performed without any difficulties [18].

After one of these techniques have been performed, the final stage of the operation is comparable. A 16–20 Fr urethral catheter is left in place. If possible the spongy tissue is closed over the urethral reconstruction (spongioplasty). A suction drain is placed and the bulbospongious muscle is closed with an absorbable 3-0 running suture over this drain. Colles' fascia is closed above the muscle using absorbable 3-0 sutures (running or separate). The skin is closed with interrupted absorbable 3-0 Donati sutures. A compressive dressing is left in place using elastic Retelast underwear.

The drain is removed after 24 hours and the patient is discharged after 24–48 hours in the absence of any postoperative complications. Early mobilization is encouraged. No specific medication is administrated to suppress spontaneous erections. A voiding cysto-urethrography is performed after one to two weeks in respectively simple and complicated cases. In case of contrast extravasation, the catheter is reinserted and the examination is repeated after one week.

In the absence of extravasation, the patient can start spontaneous voiding.

A follow-up visit with history taking and uroflowmetry is advised after three months, 12 months and annually thereafter. In case of obstructive symptoms or flow, imaging (urethrography or urethroscopy) must be performed.

13.6 Results (Table 13.1)

The success rate of the different types of non-transecting anastomotic techniques is encouraging and in line with the 93.8% composite success rate of the classic transecting excision and primary anastomosis [7]. The good results of these pioneer series suggest that there is no substantial learning curve associated with the introduction of non-transecting techniques, at least in surgeons familiar with urethral reconstruction. This was further elaborated by Lumen et al., who found no substantial learning curve in his first 75 patients [17]. The follow-up of the studies referred to is

Table 13.1 Characteristics and results of different non-transecting anastomotic urethroplasty techniques

	N	Location	Stricture length (cm)	Follow-up (months)	Success (%)	ED (%)	Post-void dribbling (%)	Complications		
								G1	G2	G3
Stricturoplasty										
Lumen et al. [4]	6	Bulbar	0.5–1	46.6	100	0	NR	NR	NR	NR
Bugeja et al. [19]	6	Bulbar	0.2	13	83.3	0	16.7	NR	NR	NR
ntEPA										
Virasoro et al. [20]	68	Bulbar	1–3	17.6	95.6	6	NR	2.9	10.3	1.5
Bugeja et al. [19]	43	Bulbar	0.2–3	13	97.7	7.1	9.3	NR	NR	NR
Lumen et al. [17]	55 20	Bulbar posterior	1–2	30	94.5 85	21.9	4.7	6.7	8	4
Gomez et al. [21]	26	Posterior	1–4.5	20	100	62	3.8	0	23.1	3.8
Le et al. [22]	12	Posterior	<2.5	6	100	^a	NR	NR	NR	NR
ANTA										
Bugeja et al. [18]	26	Bulbar	3–8	14.8	100	3.8	26.9	NR	NR	NR
Welk et al. [23]	21	Bulbar	4–5	32.4	95.2	0	85	10		

ED erectile dysfunction, ntEPA non-transecting excision and primary anastomosis, ANTA augmented non-transecting anastomosis, NR not reported

^aNo significant decline in erectile function compared to preoperative status

short and the results need confirmation in the long-term. Erectile dysfunction was not reported with the stricturoplasty series, but was observed in a subset of patients treated by ntEPA and ANTA. For bulbar strictures, this erectile dysfunction was mostly transient [17, 19]. Although in the series of Welk et al. no erectile dysfunction was observed, 27% of patients reported discomfort with erection without further details about this [23]. Post-void dribbling is not uncommon after non-transecting operations with the highest rates observed after ANTA. After tEPA, post-void dribbling is reported in 40.7% of cases [24]. As post-void dribbling is very common in patients with urethral stricture disease, most patients report improvement after urethroplasty [17, 24]. Complications are in general poorly reported. High-grade complications are uncommon (<5%).

13.7 Future Perspectives

The question whether to transect the bulbar urethra or not has been subject to widespread research over the last decade. Several urethroplasty centers shifted from the classic transecting procedure towards a routine non-transecting approach [1, 5, 17, 20, 21, 23]. The evidence of the reported results is limited by the lack of any direct comparison with tEPA. Therefore, a randomized controlled trial (RCT) comparing tEPA, ntEPA and non-transecting substitution urethroplasty for both surgical and functional outcome is definitely needed. Ideally, the aforementioned trial should aim to prove non-inferior surgical outcome of the non-transecting procedures and exploit their potential functional benefits. Hence, routine administration of validated Patient-Reported Outcome Measure (PROM) questionnaires will be of utmost importance.

Since 2011, a validated PROM questionnaire for patients undergoing urethral stricture surgery exists and should be considered standard of care in the follow-up after urethroplasty as the objective parameters evaluating urethroplasty success might substantially differ from the patient's subjective opinion [25].

Furthermore, non-transecting anastomotic procedures have also been introduced in the management of posterior urethral strictures [17, 21, 22]. So far, the presented results are auspicious, but the investigated patient cohorts are small and involve a limited follow-up. Therefore, future research is warranted to clearly establish the potential and the limits of non-transecting in this type of strictures as well.

13.8 Conclusions

NTAU is a valuable effort to reduce the surgical trauma to the urethra's vasculature formerly provoked by tEPA. The results are encouraging and the procedure is an asset in the repertoire of the reconstructive urologist dealing with strictures. The potential benefits compared to tEPA need further evaluation before NTAU can be considered the new standard procedure for short bulbar strictures.

Key Summary Points

- The urethra is well vascularized and has a triple blood supply
- Non-transecting anastomotic urethroplasty is a technical modification of the "classic" transecting anastomotic urethroplasty in which the urethra's antegrade blood flow is preserved in order to optimize the postoperative vascularization of the corpus spongiosum
- Both the non-transecting and the transecting anastomotic urethroplasty are indicated to treat short bulbar strictures.
- Stricturoplasty using the Heineke-Mikulicz principle is indicated for very short bulbar strictures (<1 cm) whereas the non-transecting excision and primary anastomosis is indicated for the somewhat longer ones (1–2.5 cm).
- The urethral patency rate of non-transecting anastomotic urethroplasty

seems to be equivalent to the transecting anastomotic urethroplasty and exceeds 90%.

- The hypothetical benefits of non-transecting anastomotic urethroplasty need to be demonstrated yet by a prospective randomized trial comparing transecting with non-transecting anastomotic urethroplasty.

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Vessel-Sparing Excision and Primary Anastomosis for Proximal Bulbar Urethral Strictures

Jessica DeLong, Gerald H. Jordan,
and Ramón Virasoro

14.1 Introduction

The most frequent cause of urethral stricture in the developed world is iatrogenic, with strictures occurring in up to 33% of patients after urologic instrumentation or procedures [1].

Stricture excision and primary anastomosis is an effective treatment option for short bulbar urethral strictures, with published long-term success rates upwards of 95% when performed in the appropriate patient by experienced surgeons [2–6]. The durability of the repair is predictable, contrary to substitution techniques, for which some authors report increasing rates of recurrence over time [7].

With the increasing prevalence of prostate cancer, and the variety of different technologies to manage primary tumors, the average reported rate of urethral stricture is 5.2% [8]. Considering that Stress Urinary Incontinence (SUI) often occurs secondary to treatment of prostate cancer, and that the current standard of care for SUI after prostate cancer treatment is the implantation of an Artificial Urinary Sphincter (AUS), cuff-related atrophy is a feared complication of the AUS. The development of techniques that preserve blood supply is logical to help mitigate this problem.

The vessel sparing technique was introduced in 2007 by Jordan et al. and initially was intended for those patients with bulbar urethral stricture after radical prostatectomy, who in the future might be candidates for an AUS [9]. The indication has since expanded to all strictures of the bulbar urethra.

Contemporary publications have begun to compare transecting and non-transecting techniques with regard to sexual outcomes, showing that there is a trend for fewer erectile dysfunction (ED) events in the non-transecting group. Chapman et al. [10] demonstrated in their cohort of 352 patients that an adverse change in sexual function was less likely in non-transecting vs transecting urethroplasty (4.3% vs 14.3%, respectively). Other studies have found similar results [11] and have further found that outcomes of non-transecting techniques are comparable to transecting techniques in terms of urethral patency [12], somewhat alleviating the concern that scar tissue excision may be incomplete in this approach.

14.2 Patient Selection

The application of stricture excision with primary repair is limited by the length and the location of the scar, and should be used to repair the bulbar urethra. Excision with primary anastomosis of the penile urethra may risk the creation of

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chordee, as this area is not as mobile. The Vessel Sparing (VS) technique follows the same rule, with the ideal patient having a short proximal bulbar urethral stricture. Both traumatic and non-traumatic etiologies could be managed with this technique, and even recurrent urethral strictures can be favored with a VS-EPA. Some surgeons use a cut off length of 2 cm for stricture excision and primary anastomosis, while others make the decision intra-operatively based on the inner elasticity of the corpus spongiosum. There remains some controversy regarding the optimal management of bulbar strictures, with some authors favoring augmented repairs depending upon etiology [12, 13].

Initially, the vessel sparing technique was described for those patients with a urethral stricture after radical prostatectomy. The hypothesis was that by preserving the proximal blood supply of the corpus spongiosum, we could lessen the risk of cuff associated atrophy in the event these patients may require the placement of an AUS in the future. Later on, as we became more confident with the technique, we applied it to other scenarios, provided that the stricture could be excised and anastomosed without tension. We even started using the vessel sparing technique for augmented anastomotic urethroplasty, and others have followed the trend [14].

Currently we apply the VS technique to any patient with a bulbar stricture who is a candidate for excision and primary anastomosis or augmented anastomotic urethroplasty. Although posterior urethral reconstruction will be described elsewhere in this book, is noteworthy that the vessel sparing technique can be applied in this scenario [15].

14.3 Preoperative Evaluation

Preparation for surgery includes a thorough history, physical examination, routine laboratory tests, and an evaluation of the stricture. Characterization of the anatomy of the stricture includes urethral X-rays, and endoscopic evaluation to define location, length and caliber of the stricture, as well as health of the urethral mucosa

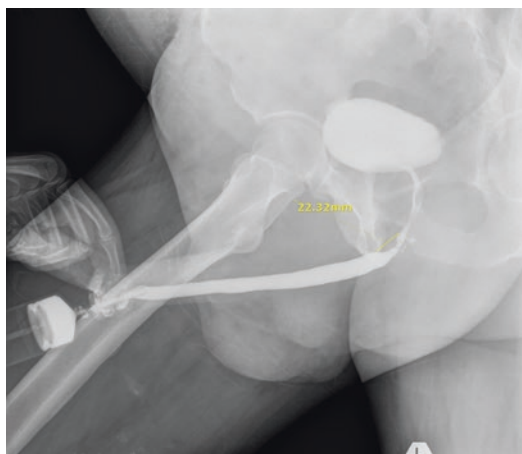


Fig. 14.1 Preoperative retrograde urethrogram showing the stricture at the proximal bulbar urethra

distal to the stricture. The authors believe that the combination of dynamic antegrade and retrograde radiographic views is essential to determine the length of the urethral stricture, and for this purpose, we prefer to do our own urethral X-ray evaluation (Fig. 14.1). Some centers use perioperative urethral ultrasonography to assess degree of spongiofibrosis [16]. We use validated questionnaires to assess degree of urinary bother as well as erectile function.

Patients must have a sterile urine culture at the time of surgery. If necessary, patients are admitted for inpatient treatment with broad-spectrum IV antibiotics peri-operatively. In diabetic patients we recommend strict perioperative blood glucose control and generally require a preoperative glycosylated hemoglobin of less than 7%. Although studies are controversial regarding the role of hyperglycemia and increased perioperative infection, there is data that supports increased risk of infection and wound healing complications associated with poorly controlled diabetes [17].

14.4 Surgical Technique

Under general anesthesia the lower abdomen, genitalia and perineum are shaved. If a suprapubic tube is present this is exchanged sterilely. We

are not placing suprapubic tubes at the time of surgery in patients who did not already have one placed preoperatively. The lower abdomen, genitalia and perineum are prepped and draped sterilely. Either high lithotomy or “social lithotomy” may be used.

Traditionally the urethra was approached via a lambda shaped perineal incision; we now prefer a midline longitudinal perineal incision. The skin and subcutaneous tissues are divided with a combination of sharp dissection and electrocautery. The ischiocavernosus muscle is separated from the corpus spongiosum (Fig. 14.2).

The perineal Jordan-Simpson retractor is placed for exposure. The bulbospongiosum is separated from the perineal body in the midline without disrupting the proximal blood supply. A muscle-sparing approach can be utilized if desired. The corpus spongiosum is detached from the corpora cavernosa, dissecting distally to the penoscrotal junction. Mobility and length is gained by dissecting Buck’s fascia from the corpus spongiosum. The membranous urethra and the proximal vascular structures are dissected free from surrounding tissues (Fig. 14.3).

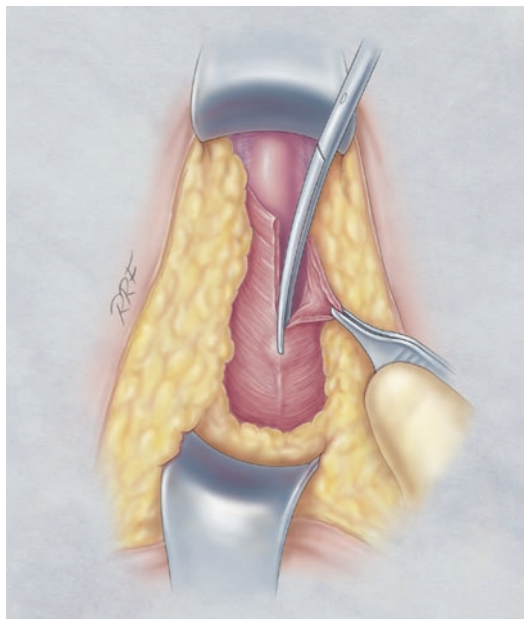


Fig. 14.2 The ischiocavernosus is detached from the corpus spongiosum

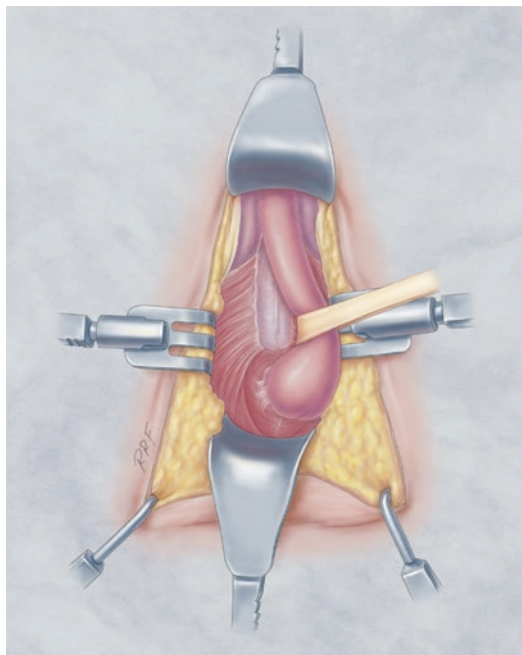


Fig. 14.3 The membranous urethra and the proximal vascular structures are dissected free from surrounding tissues

If indicated, the triangular ligament is divided and the intracanal space is separated. The space between the membranous urethra and the proximal vasculature is developed and a vessel loop is used to retract caudad on the vascular structures, exposing the membranous and proximal bulbar urethra. In this step, the bulbar arteries are preserved (Fig. 14.4).

The distal extent of the stricture is marked either by passing a flexible cystoscope or a large bore (e.g. 18 French) bougie or catheter. The stricture is excised, and the urethral lumen spatulated until healthy urethra is encountered in both directions (Fig. 14.5). The urethra is calibrated and should accommodate a bougie of 30 French.

Eight to 10 anastomotic sutures are placed with the knots on the outside of the mucosa. Our preference is 4-0 and 5-0 PDS (Fig. 14.6). Once all sutures are placed, they are parachuted in and a 14 Fr stenting urethral catheter is placed (Photo 14.1). Irrigation with antibiotic solution is used. The bulbospongiosum, if divided, is reattached in the midline with a series of interrupted 4-0 PDS suture. A 10 French TLS drain is placed deep to

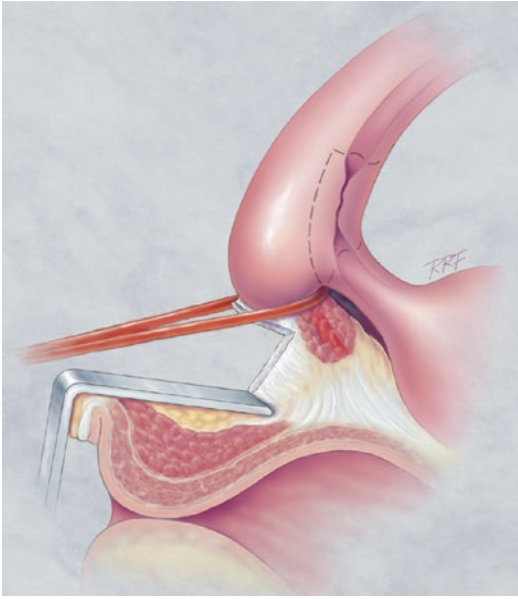


Fig. 14.4 Vessel loop is defining the plane between the bulbospongiosum (with the bulbourethral arteries within) and the bulbomembranous urethra

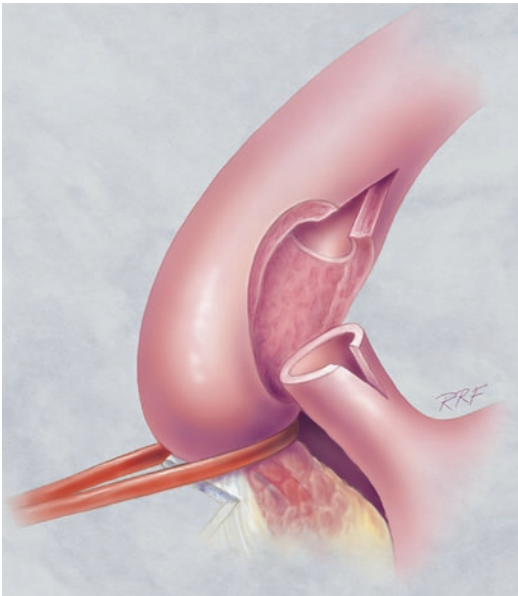


Fig. 14.5 The stricture is excised, and the urethral lumen spatulated until healthy urethra is encountered in both directions

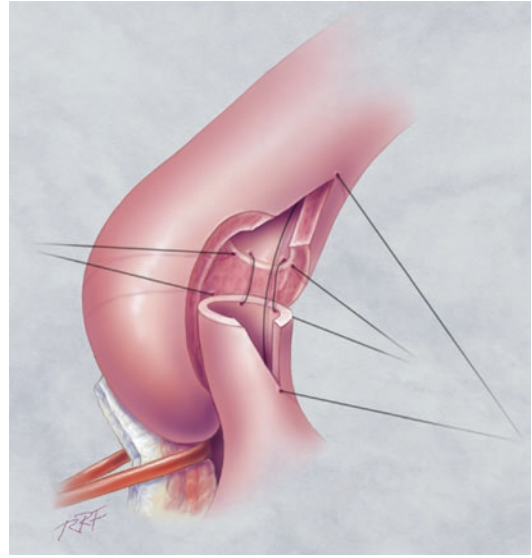


Fig. 14.6 Eight to 10 sutures are placed and parachuted in

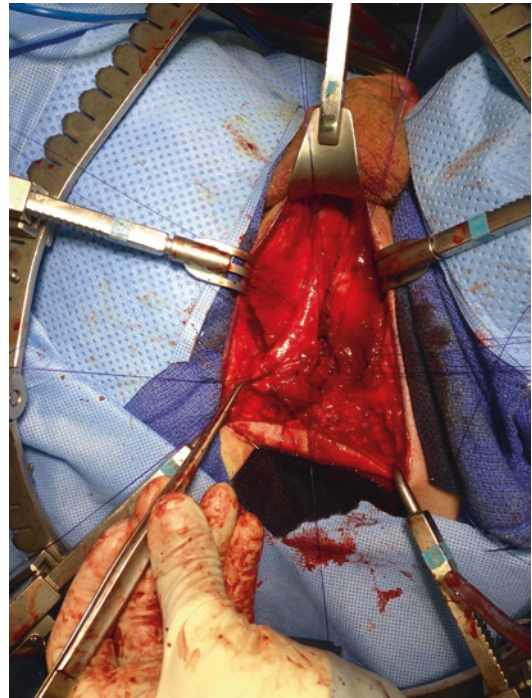


Photo 14.1 Strictured urethra has been removed without transecting the proximal bulbar blood supply. An end-to-end anastomosis is performed in the same fashion as traditional EPA

the muscle when indicated and brought out through a separate stab incision in the scrotum. The subcutaneous structures are closed in layers with absorbable suture, and the skin is closed with a 4-0 Monocryl suture. Skin glue is applied with no additional dressing necessary [18].

14.5 Preferred Instruments

- Sequential compression devices
- Yellowfin® stirrups, (Allen Medical Systems, Acton MA)
- Jordan-Simpson segmented perineal retractor (CS Surgical Inc., Slidell LA)
- 17 Fr flexible cystoscope
- Delicate sharp scissors (Tenotomy)
- Delicate forceps (Debakey)
- 4-0 and 5-0 PDS suture
- Silicone 14-16 Fr. Foley catheter

14.6 Postoperative Care and Follow Up

The surgical wound is covered with surgical glue. The stenting urethral catheter is affixed to the lower abdomen to prevent pulling. The suprapubic catheter, if present, as well as potential drains, are dressed and also affixed to the abdomen. If a suprapubic tube is present this is used preferentially to drain the bladder and the urethral catheter is capped. The patient is treated with broad-spectrum intra venous antibiotics for 24 hours, and will receive bactericidal doses 2 days prior to catheter removal. The patient is also treated with analgesics, bladder antispasmodics, stool softeners, and in selected patients, with amyl nitrate and/or valium to help prevent erections. The patient is allowed to ambulate ad libitum, and is discharged on postoperative day 1. The patient is instructed to avoid sitting erect as long as the urethral catheter is in place.

At approximately 21 days after surgery the patient is assessed in the office, where the urethral stent is removed and a voiding cystourethrogram is performed (Fig. 14.7). If there is no



Fig. 14.7 Postoperative VCUG showing normal urethral caliber and almost non-identifiable anastomosis area

extravasation of contrast, the catheter is left out. If present, the suprapubic catheter is plugged, and can be removed 2–3 days later as long as the patient continues to void per urethra without difficulty.

The patient is seen at 3 months postoperatively and assessed with validated questionnaires, a post void residual and simple uroflowmetry. A flexible urethroscopy is performed approximately 6 months after surgery to demonstrate urethral patency. An office appointment is scheduled at one year after surgery, with a yearly follow-up thereafter (either in our office or with the referring urologist). The long-term follow-up relies mainly on patient symptoms (subjective diminished force-of-stream, UTI, urinary retention, etc.), while diagnostic procedures such as urethroscopy and/or retrograde urethrogram are done selectively. Many centers are using patient reported outcome measures (PROMs) specific to urethroplasty to help follow patients. This may allow for improved follow up as well as more realistic patient-centered data reporting [19].

14.7 Results and Clinical Outcomes

After the initial series of ten patients by Jordan et al. in 2007, with 100% success at a mean follow up of 12 months, other centers have adapted the technique and larger studies have been

completed. Similarly, Andrich and Mundy, in 2011, had a 100% success rate in their initial series of non-transecting urethroplasty after 12 months. In an effort to prove reproducibility and durability of the technique, an international collaboration of five different centers in the United States, South America and Europe gathered their experience with the VS-EPA. In that retrospective series of 68 patients receiving VS-EPA 95% of patients had a widely patent anastomosis after a mean follow-up of 17 months [20]. Bugeja and Mundy then reported their follow up series, now including 67 patients, who received one of the variations of their non-transecting techniques, including BMG-AAU, and after a mean follow up of 13 months, 97% of the patients were radiologically stricture free [21]. This series shows that the vessel-sparing technique for bulbar urethral reconstruction is reproducible, widely applicable and reliable. In their work Chapman et al. showed that patients undergoing transecting urethroplasty were more likely to have a negative change in erectile function than those undergoing the VS technique, 14.3% vs 4.3%, respectively [10].

14.8 Discussion

It was not until we had a complete understanding of the anatomy of the genitourinary tract that modern reconstructive urology flourished. In the past 20 years, we have experienced significant advances in urethral reconstruction, most of which are the result of the knowledge of the anatomy, understanding of the mechanism of the diseases, adopted protocols for evaluation and follow up, standardized surgical approaches and tissue handling techniques.

We are now facing a potential new paradigm in urethral reconstruction that makes every effort to preserve noble structures such as blood vessels, nerves and muscles. Over the last 10 years, several publications have challenged traditional, very successful surgical techniques. Surgeons are endeavoring to improve results by sparing anatomic structures in order to preserve sexual function, and proactively prevent further complications.

The concept of vessel preservation is not new, as it was proposed by Mr. Richard Turner-Warwick when he postulated a two-layer bulbar urethral anastomosis in order to restore continuity of the spongiosum tissue, with its potential revascularization [22]. It was not until 2007, when Jordan and colleagues published their first series of the vessel-sparing technique, that a new concept in urethral reconstruction was begun [9]. This was done by sparing the proximal blood supply of the corpus spongiosum without compromising the critical steps of the traditional EPA. The initial indication was to preserve the blood supply of the spongiosum in patients with anterior urethral strictures after radical prostatectomy. The rationale was that these patients may need an Artificial Urinary Sphincter (AUS) in the future, hence by preserving the blood supply of the spongiosum, we may prevent AUS cuff-related atrophy. Later, the indication was expanded to all proximal bulbar urethral strictures, as the technique was rendered feasible and safe. The potential for benefit was also recognized in patients with a history of hypospadias and those with synchronous strictures [23]. Many centers around the world have corroborated reproducibility of the technique and outcomes, and the indication further expanded to Augmented Anastomotic Urethroplasty (AAU). Following Jordan's initial report, others embraced the principle of the vessel-sparing concept, publishing variations and adaptations of the technique [11, 14, 21]. The recent publication from Chapman et al. in Alberta, Canada [10], proposes that preserving the spongiosum blood supply may have a positive impact on sexual function, but until well designed, randomized studies are done, comparing traditional EPA vs VS-EPA in terms of outcomes will remain a challenge.

14.9 Conclusions

The goals for the vessel sparing technique in the bulbar urethra are to obtain equivalent and durable outcomes to traditional EPA while preserving the proximal vasculature of the corpus spongiosum. The approach is logical and advantageous in

theory, and series from many centers around the world have confirmed safety and equivalent efficacy. Mid- and long-term follow-up from the original series as well as contemporary studies support durable results equivalent to traditional techniques.

The VS-EPA technique was initially utilized for application in the bulbar urethra, however since its introduction has been applied to all segments of the urethra. A well designed prospective randomized clinical trial comparing traditional EPA and VS-EPA with comprehensive and validated data regarding erectile function, quality of life and urethral patency outcomes will determine if preserving the proximal blood supply is a valuable step forward in urethral reconstruction.

Key Summary Points

- We may be experiencing a paradigm shift in reconstructive urology, where preservation of anatomical structures seeks to preserve function.
- Urethroplasty is one of the mainstays of reconstructive urology, with many successful approaches.
- Traditional urethroplasty has been based on the concept of dual blood supply of the corpus spongiosum; in the majority of cases this may be appropriate, however selected cases may benefit from proximal vascular preservation.
- Vessel sparing urethroplasty is feasible and reproducible, but may have a significant learning curve.
- We need better evidence than what has traditionally been used; many decisions are based on low levels of evidence with low recommendation grades.
- The future of reliable reconstructive urology depends on well-designed and conducted clinical trials.

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Role of Transection and Anastomosis in Bulbar Urethral Reconstruction

15

Jason P. Joseph, Allen F. Morey, and Boyd R. Viers

15.1 Etiology of Bulbar Urethral Strictures

The incidence of male urethral stricture disease is greatest in the bulbar urethra, comprising at least 47% of all strictures treated [1, 2]. It is therefore important for the reconstructive urologist to become familiar with effective and durable treatment solutions for bulbar urethral stricture disease. We favor the technique of excision and primary end-to-end anastomosis (EPA) whenever possible.

Contemporary series suggest the four most common stricture etiologies include idiopathic (37%), iatrogenic (28%), post-traumatic (15%), and inflammatory (11%), the latter including lichen sclerosis [1, 3–6]. While idiopathic urethral strictures remain poorly understood, they tend to be found in the bulbar urethra (91%), relatively short ($60\% \leq 2$ cm), and associated with a remote history of repetitive trauma [3]. These findings suggest that the most common etiology of bulbar urethral stricture disease, idiopathic strictures, may be the eventual consequence of

unrecognized urethral injury and activities associated with repetitive subacute perineal trauma such as cycling, motocross, and horseback riding [3, 7]. Fortunately, idiopathic urethral strictures tend to be associated with excellent reconstructive success (>95% five year success) after urethroplasty [4].

Iatrogenic anterior urethral strictures are most commonly associated with previous endoscopic instrumentation, particularly transurethral resection (TUR), and prolonged urethral catheterization [6, 8]. Additional iatrogenic risk factors include prior pelvic radiotherapy and hypospadias surgery. Iatrogenic strictures more frequently occur in the penile urethra, though lesions in the bulbar urethra – specifically the bulbopendulous and bulbomembranous junction – may be amenable to anastomotic urethroplasty [6].

Acute traumatic strictures of the bulbar urethra most often occur following a straddle injury, during which blunt perineal trauma causes compression of the urethra against the pubic symphysis. This leads to some combination of loss of urethral continuity, urine extravasation, and hemorrhage, thereby precipitating inflammation and spongiofibrosis [9]. Patients may present with history of acute perineal trauma, inability to void, and blood at the urethral meatus. Resultant bulbar urethral strictures are commonly focal and obliterative in nature, often with complete transmural spongiofibrosis. These patients have excellent results with delayed primary anastomotic urethroplasty following a period of urethral rest.

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15.2 Patient Selection

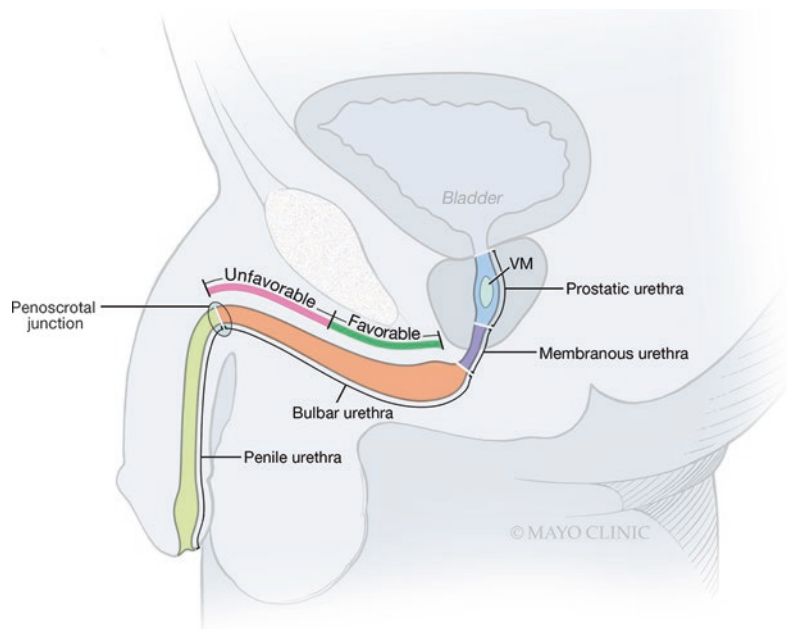
To optimize success and minimize risk of morbidity, appropriate patient selection is paramount. The technical objectives of anastomotic urethroplasty include complete excision of the diseased segment with formation of a wide spongiosal sparing anastomosis. A 1 cm spatulation of both proximal and distal segments can help facilitate formation of a wide (>26 Fr), oblique anastomosis, thereby reducing the risk of annular retraction and stricture recurrence. When considering the length of the excised segment, as well as the degree of proximal and distal mobilization needed to facilitate a spatulated, tension-free anastomosis, stricture length, location, and degree of spongiobrosis are the most important considerations.

The penile urethra lacks elasticity, has a paucity of ventral spongiosum, and obtains substantial collateralizing blood supply from perforating vessels along the corpora cavernosa. These characteristics in combination with the often lengthy and multi-focal nature of penile urethral stricture disease limit the use of anastomotic urethroplasty techniques. In highly select men with focal (<1 cm) obliterative strictures of the proximal penile urethra, primary excision, distal bulbar urethra mobilization, and reanastomosis may

provide a durable reconstructive solution without a detrimental impact to sexual function [10]. Nonetheless, despite a possible evolving role for EPA in highly selected men with focal penile urethral strictures, this is uncommon in practice, and therefore will not be discussed here in detail.

With adequate mobilization of the bulbar urethra, proximally to the membranous urethra and distally to the penoscrotal junction, a tension-free primary anastomosis can be performed to bridge sizeable defects. Urethral elongation relies upon the natural elasticity bulbar urethra where there is robust, well vascularized, and redundant ventral spongiosum. Importantly, bulbar strictures amenable to EPA depend not only on stricture length but also on the relative location. In general, strictures 2 cm or less are amenable to anastomotic urethroplasty at any location within the bulbar urethra. For lengthier strictures (3–5 cm), extended anastomotic urethroplasty can be performed for defects of the mid to proximal bulbar urethra with excellent outcomes [11]. Further, for men with greater than average stretched penile length (14 cm or greater) and strictures located in the mid to proximal perineum, tension-free extended anastomotic urethroplasty can be effectively performed for strictures exceeding 5 cm (Fig. 15.1) [12]. Conversely, in our analysis of 40 men with distal

Fig. 15.1 The proximal bulbar urethra is favorable for extended anastomotic urethroplasty for strictures up to 5 cm; the distal bulbar urethra is unfavorable for extended anastomotic urethroplasty and anastomotic urethroplasty in this location should be limited to strictures <2 cm; VM verumontanum



bulbar strictures and median stricture length of 3.75 cm, 90% of cases required augmentation with substitution techniques (graft or flap) based on the intraoperative determination that a tension-free primary anastomosis could not be achieved [11].

Despite a well-executed preoperative staging evaluation, the decision to proceed with EPA is finally determined with intraoperative assessment. Patients should be counseled that inability to effectively excise all scar and achieve a tension-free anastomosis may necessitate an augmented reconstruction with substitution techniques to optimize outcomes.

15.3 Preoperative Evaluation

Meticulous preoperative evaluation is necessary to facilitate surgical approach and optimize outcomes after anastomotic urethroplasty. A thorough preoperative evaluation consists of several clinical and radiographic considerations as described below.

15.3.1 History

History should include an assessment of urinary symptoms and sexual function, creating a documented baseline for postoperative comparison and to guide counseling on postoperative expectations. Standardized questionnaires (American Urological Association Symptom Index, International Index of Erectile Function, etc.) are useful to objectively quantify pre and postoperative urinary and sexual function.

While the majority bulbar urethral strictures are idiopathic, it is essential that the surgeon attempts to determine stricture etiology as this will influence candidacy for anastomotic urethroplasty and expected outcomes. Historical elements of significance include any prior perineal or pelvic trauma and relative timing, urinary tract instrumentation including urethral catheterization, and review of prior urologic and non-urologic surgeries, eliciting detail regarding any history of perioperative bladder catheterization or traumatic catheterization. Men with iatrogenic strictures abutting the membranous urethra fol-

lowing BPH surgery must be counseled that any EPA technique may predispose to de novo stress incontinence postoperatively. Additionally, men with inflammatory and radiation induced urethral stricture disease should be counselled on a greater incidence of stricture recurrence relative to those with idiopathic, iatrogenic, or traumatic stricture etiologies [3].

Urologic instrumentation history should be specifically evaluated, with special attention to history (including frequency and timing) of indwelling or intermittent catheterization, urethral dilation, internal urethrotomy, and prior stricture surgeries. Corresponding operative reports should be reviewed if available, as these procedures may have implications on anticipated anatomic relationships, vascular supply, and stricture complexity [13]. It is crucial to determine the timing of most recent urethral instrumentation. We suggest 6–8 weeks of “urethral rest” following any urethral intervention prior to preoperative staging and consideration of urethroplasty [14] in order to accurately characterize the urethral stricture.

Additional risk factors for impaired urethral perfusion should also be elicited, including history of diabetes mellitus, peripheral vascular disease, tobacco use, vasculogenic erectile dysfunction, or prior pelvic radiation. In patients with history of pelvic trauma, details regarding any prior pelvic angioembolization; compromise to even a unilateral internal pudendal artery, which gives rise to the ipsilateral dorsal, cavernous, and bulbar arteries, will have implications on anastomotic perfusion and erectile function postoperatively. Any neurologic disease or prior surgery (spine surgery, abdominoperineal resection, low anterior resection, etc.) placing the patient at risk for voiding and erectile dysfunction, should be noted.

15.3.2 Physical Examination

A focused genitourinary exam is crucial. Examination of the urethral meatus, fossa navicularis, ventral penile shaft, and perineum, both visually and by palpation, should enable documentation of phimosis, lichen sclerosis, prior scars, fistulae, erythema, or palpable induration,

the latter frequently correlating with underlying spongiofibrosis. Testicular atrophy and general health of the surrounding genital tissue are a good indication of occult hypogonadism, a process that has been associated with urethral atrophy and decreased vascularity of the male urethra [15, 16]. Evidence and degree of stress urinary incontinence is useful to guide patient expectations postoperatively, direct operative approach (transecting vs non-transecting), and the need for future interventions which may require perineal dissection for male stress incontinence surgery. Chronic urine soilage of the perineum and intertriginous folds can be associated with fungal and/or bacterial infection, which may complicate incisional healing postoperatively. Stretched penile length (SPL) is useful to establish a baseline prior to reconstruction and guide patient selection for extended bulbar anastomotic urethroplasty, which is facilitated by increasing penile length [12].

BMI should be considered, as obesity can pose challenges in achieving adequate surgical exposure, increases the risk of positioning-related neuromuscular complications, and may be associated with increased likelihood of stricture recurrence [17]. Given the high lithotomy position which is required for bulbar urethral exposure, mobility of the bilateral lower extremities, particularly at the hips and knees, and neuromuscular function should be evaluated.

15.3.3 Radiographic and Endoscopic Evaluation

Radiographic and endoscopic evaluation provides the surgeon with an understanding of patient-specific urethral anatomy; this is crucial to appropriately select candidates for anastomotic bulbar urethroplasty. It is necessary to stop all urethral instrumentation for a period of time before surgical reconstruction. In men presenting with indwelling catheters, chronic intermittent self-catheterization, or recent endoscopic instrumentation (dilation, DVIU, etc.), we recommend suprapubic cystostomy or a trial of spontaneous voiding for at least 6–8 weeks to allow for scar maturation and stabilization, before stricture staging and definitive reconstruction [14].

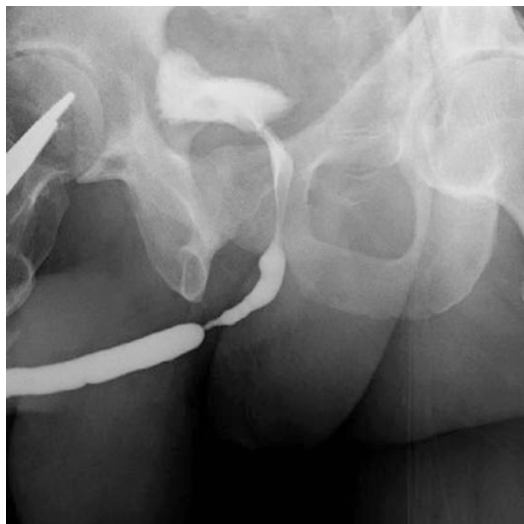


Fig. 15.2 Retrograde urethrogram demonstrating a focally high-grade 2 cm mid bulbar urethral stricture

A retrograde urethrogram (RUG) (Fig. 15.2) performed in the oblique position is necessary to define urethral anatomy and characterize stricture length, location, diameter, and density. Voiding cystourethrography (VCUG) is a useful staging adjunct that can often be performed simultaneously with RUG to more accurately characterize the proximal extent of disease [18, 19]. VCUG provides dynamic information regarding bladder capacity, vesicoureteral reflux, cystographic evidence of detrusor dysfunction, and bladder neck competency during both storage and voiding. For non-obliterative lesions, VCUG can be obtained after the bladder is sufficiently filled with contrast in a retrograde fashion. Retrograde passage of a small open-ended ureteral catheter into the bladder for contrast instillation for VCUG has been described, though we caution against this practice due to the theoretical risk of dilating and/or distorting the stricture. Finally, VCUG can be obtained using antegrade contrast instillation in patients with indwelling suprapubic catheters. When feasible, our preference is for combined RUG and VCUG to achieve a thorough, synergistic evaluation of the urethra.

Preoperative flexible urethroscopy is a useful tool to assess urethral anatomy, characterize stricture density, and identify any suspicious lesions that warrant biopsy. We reserve preoperative urethroscopy for those men with stricture

recurrence following prior urethroplasty and those with rapid stricture recurrence following endoscopic management to rule out malignant transformation. Urethroscopy is useful to characterize the relationship between the stricture and the membranous urethral sphincter in those with prior bladder outlet surgery, as well as those men with prior radiation to assess adjacent urethral integrity and vascularity. In men with indwelling suprapubic catheters, antegrade cystourethroscopy can also be performed. While not routinely used in our practice, ultrasonography and MRI provide accurate stricture staging evaluation and may be useful adjuncts in the identification of associated pathology such as fistulae, diverticulae, abscesses, and false passages [19].

15.4 Presurgical Preparation

Prophylactic guideline specific parenteral antibiotics are administered prior to incision, and in men with positive preoperative urine cultures, targeted antibiotic therapy should be implemented. Men with incomplete bladder emptying, recent instrumentation, or indwelling suprapubic catheters, often have urinary bacterial colonization. In these patients, we prefer to initiate culture directed prophylaxis starting three days before surgery to sterilize the urine. For those men without such risk factors, we do not initiate preoperative antibiotic therapy, as prophylaxis administered the day of surgery is typically sufficient to prevent postoperative infection. Venous thromboembolism prophylaxis includes lower extremity sequential compression devices intraoperatively and early postoperative ambulation.

Positioning should foremost optimize patient safety, but also maximize technical ergonomics and surgeon comfort. Bulbar urethroplasty is best performed in a high lithotomy position, thereby rotating the pubic ring anteriorly and cephalad while providing excellent perineal exposure. This exposure can be further facilitated by with a slight Trendelenburg position. We utilize Yellofin stirrups with careful attention to lower extremity positioning, to reduce the risk of peroneal nerve compression injury. The patient's buttocks is brought just beyond the end of the operating table



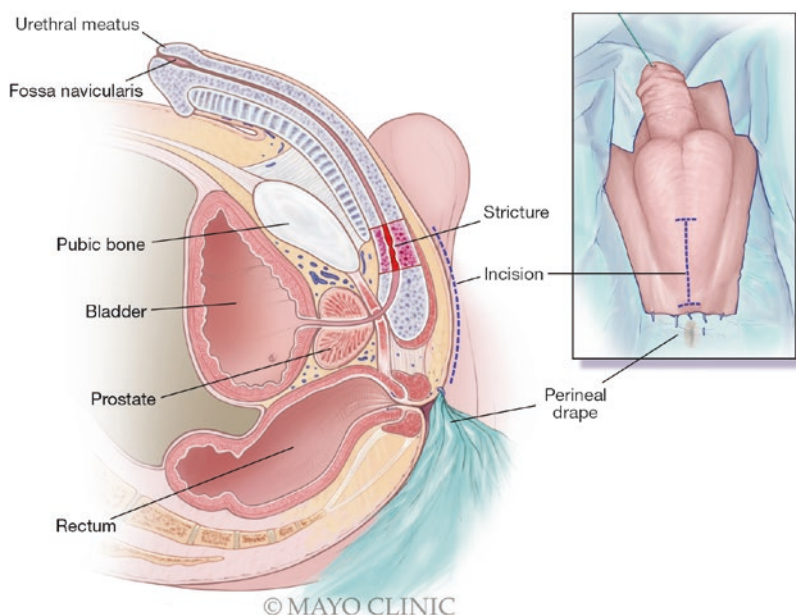
Fig. 15.3 Positioning for transperineal anastomotic bulbar urethroplasty

to minimize distance between the surgeon and target anatomy, as well as to prevent interference between the operative table and the overlying drape or self-retaining retractor. The arms are secured to armboards with slight abduction and flexion at the elbow, reducing stretch on the brachial plexus. All pressure points are carefully padded (Fig. 15.3).

The risk of positioning-related complications, such as rhabdomyolysis, compartment syndrome, and peroneal neuropraxia, can be minimized by limiting the duration of exaggerated lithotomy positioning; these complications are uncommon when operative duration does not exceed 5 hours [20]. Relative to alternative reconstructive techniques, anastomotic urethroplasty of the bulbar urethra is a time efficient operation with operative times that rarely exceed 4 hours. Nevertheless, we recommend limiting the duration of high and exaggerated lithotomy positioning whenever possible. A low or standard lithotomy position may provide sufficient exposure for more distal bulbar lesions. In our practice during portions of the operation such as wound closure, where high lithotomy is not necessary, we routinely lower the legs into standard or low lithotomy position.

Using electric clippers, all hair is carefully removed from the perineal and genital region. Epidermal abrasions should be avoided as these may be a potential entry point for bacteria, thereby increasing the risk of surgical site infection. Chlorhexidine skin preparation is performed from the umbilicus to the mid-thigh, including the genitalia and perineum. The sterile field includes the suprapubic region to facilitate ante-

Fig. 15.4 The perineal drape is secured just anterior to the anal verge as shown, maintaining surgeon orientation during initial transperineal dissection in a plane parallel to the rectum



grade access if a suprapubic tube is in place, or in the event that one is needed.

We prefer a systematic approach to draping, which can help aid in surgeon orientation. Sterile blue towels are applied to “square” the field, and most notably the posterior towel is secured with staples immediately anterior to the anal verge, exposing the entirety of the perineum (Fig. 15.4). This allows the surgeon to maintain orientation in a plane of dissection that is parallel to the rectum when approaching the proximal bulbar urethra. On the contrary, more anterior towel placement without complete exposure of the perineum would require the surgeon to proceed in a plane obliquely towards the anterior rectal wall. The perineal drape is next secured to the underlying towels and the perineal skin with additional staples. A lithotomy drape with an integrated under buttocks pouch is an excellent system to effectively manage fluid spillage from the field.

15.5 Operative Technique

Retrograde endoscopic evaluation with a flexible cystoscope allows for a final evaluation of the anterior urethra, and precise confirmation and localization of the distal aspect of the stricture.

Aggressive attempts to negotiate the scope proximal to the stricture are not made, but if the surgeon is able to smoothly negotiate a 17 Fr cystoscope through the stricture without resistance, the procedure should be terminated. For non-obliterative strictures, proximal access is secured by passing a flexible guidewire (0.035 in. diameter) into the bladder. Palpating the wire can expedite initial perineal dissection, particularly in obese patients and reoperative fields. If the stricture is obliterative, intraoperative antegrade urethroscopy can facilitate localization of the proximal non-diseased urethra. We caution against the practice of only securing proximal access after transection for proximal bulbar lesions; in a bloody operative field this can be highly challenging, risking loss of tissue planes and potential adverse outcomes.

The cystoscope is removed and the safety wire is secured out of the field. A vertical mid-line incision is made sharply along the perineal raphe from the perineoscrotal junction anteriorly, and carried down to approximately 1 cm above the anal verge (Fig. 15.4). For mid to distal strictures where additional distal urethral mobilization may be needed, this incision can be extended anteriorly onto the base of the scrotum. We have abandoned use of the lambda

incision for transperineal urethroplasty due to increased risk of postoperative wound complications [21]. The incision is deepened through the subcutaneous tissue with electrocautery, following which a self-retaining retractor is placed. We prefer use of the Lone-Star self-retaining retractor system (Cooper Surgical, Trumbull, CT, USA), and tend to place this promptly. Eight blunt hooks (sharp hooks for reoperative cases) are placed circumferentially, with laterally placed hooks applying excellent lateral traction thereby facilitating efficient electrocautery dissection through Colles fascia and the perineal fat down to the bulbospongiosus muscle. In men with an abundance of perineal or scrotal fat, it can be helpful to dynamically reposition the hooks and utilize small hand-held retractors as the dissection is deepened, maximizing visualization until there is satisfactory exposure. Two four-finger rake retractors are secured to the retractor at the 10 and 2 o'clock positions to elevate the scrotal contents out of the field.

The bulbospongiosus muscle is sharply divided in the midline (Fig. 15.5). Alternatives include lateral mobilization of the muscle, or dissection of the muscle away from the underlying

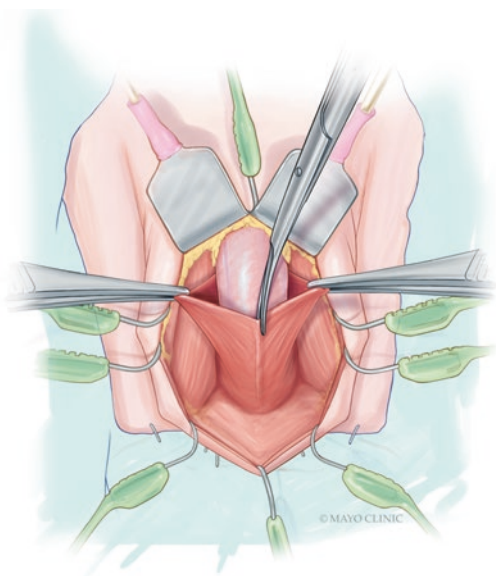


Fig. 15.5 Sharp midline division of the bulbospongiosus muscle



Fig. 15.6 Blunt hooks for the self-retaining retractor are repositioned, incorporating the divided bulbospongiosus muscle, facilitating exposure of the underlying corpus spongiosum

spongiosum and retracting it proximally. We prefer a sharp midline division of the muscle and primary reapproximation during closure as it efficiently facilitates bulbar urethra visualization without evidence to suggest that doing so compromises antegrade ejaculation or causes urinary dribbling. Once the muscle is divided, the blunt hooks are repositioned to retract the muscle away from the underlying corpus spongiosum, as this facilitates further proximal dissection ventrally, including exposure of the proximal bulb and central tendon of the perineum (Fig. 15.6).

After complete ventral exposure of the bulbar corpus spongiosum, attention is turned to circumferential mobilization. Our approach is to sharply mobilize the lateral and dorsolateral attachments working from side-to-side, thus isolating the dorsal spongiosal attachments to the ventral corporal bodies. With care taken to avoid inadvertent corporotomy, a right angle is passed dorsally to complete focal circumferential mobilization, and a vessel loop is passed around the urethra. The vessel loop is dynamically retracted by the assistant to create atraumatic counter traction, facilitating ongoing sharp division of the dorsal septum and urethral lengthening proximally and distally (Fig. 15.7).

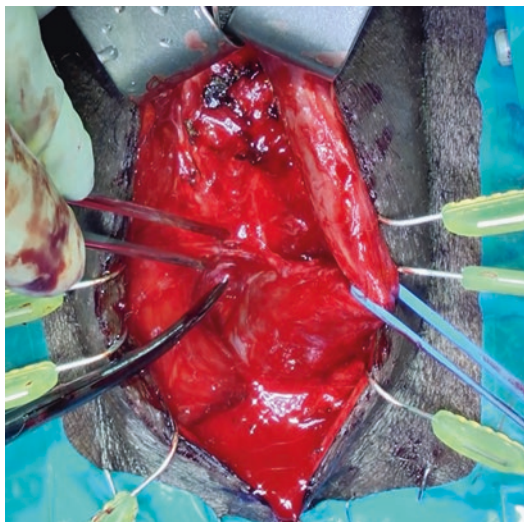


Fig. 15.7 Following circumferential exposure distally, a vessel loop facilitates atraumatic retraction during additional proximal bulbar mobilization

The bulbar urethra should be mobilized to the penoscrotal junction within the avascular plane between Buck's fascia and the tunica spongiosum. During the course of mobilization, should inadvertent corporotomy or entry into the spongiosal tunica occur, these can be primarily repaired with 4-0 polyglactin suture to control bleeding, which might otherwise impair intraoperative visualization or increase the risk of postoperative hematoma. For strictures at or proximal to the mid bulbar urethra, we prefer to place a Beckman-Weitlaner self-retaining retractor to aid with proximal bulbar exposure (Fig. 15.8). The urethral bulb is mobilized proximally, and for all but distal bulbar lesions and select focal mid to proximal lesions, this will entail sharp transection of the central tendon of the perineal body to fully mobilize and advance the bulb.

The paired bulbourethral arteries, branches of the paired internal pudendal arteries, perforate the anterior pelvic floor triangle and enter the base of the bulbar urethra at the 4 and 8 o'clock position. These vital bulbar arteries should be prospectively identified and avoided when possible; this will maximize antegrade anastomotic perfusion, theoretically reducing the risk of ischemic recurrence, particularly in men with impaired urethral vascularity [22]. In men with

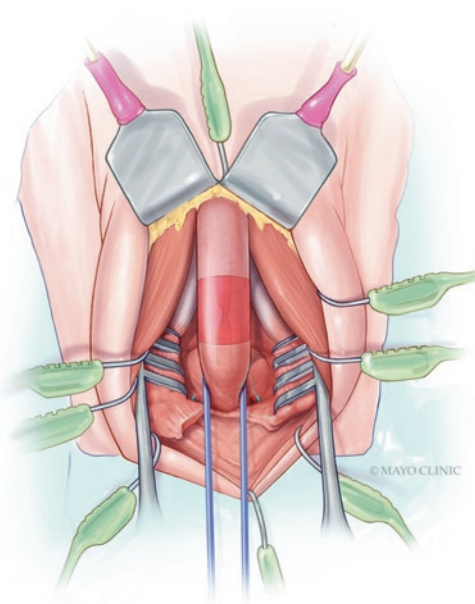


Fig. 15.8 A Beckman-Weitlaner self-retaining retractor can be utilized to further aid with proximal bulbar exposure

concurrent stress urinary incontinence requiring staged artificial urinary sphincter, maximizing bulbar urethral perfusion is important to reduce the risk of urethral cuff erosion [23]. Though rarely necessary in our practice, the natural curve of the bulbar urethra, largely generated by the proximal fusion of the corporal bodies superiorly with the bulbar urethra curving in concave fashion below and coursing cephalad towards the bulbomembranous junction, can be straightened by incising and splitting the intercrural septum, affording additional mobilization [24].

After sufficient mobilization of the bulbar urethra is complete, attention is turned to localization of the stricture. Multiple techniques exist for precise identification of the distal aspect of the stricture, including passing a sound via the meatus (soft urethral catheter, or Bougie-à-Boule), as well as flexible urethroscopy. We prefer the latter, and once the distal aspect of the stricture is identified endoscopically, the corresponding location on the ventral bulbar spongiosal tunica is identified and marked with electrocautery. Regardless of the technique chosen, it is important to avoid erring distally, which would otherwise sacrifice healthy urethral length.

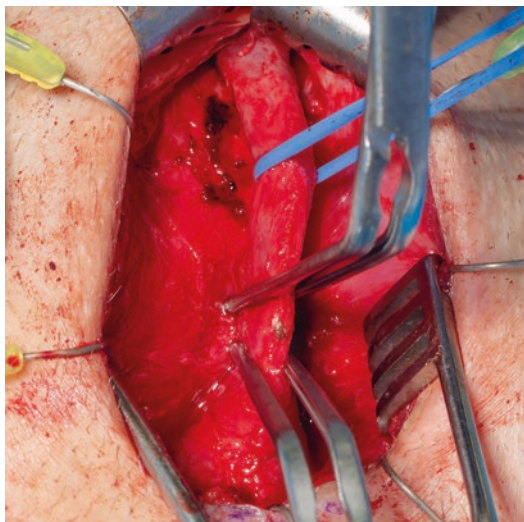


Fig. 15.9 Angled vascular clamps are applied across the urethra, flanking the anticipated distal margin of the stricture; the clamps provide stabilization and improve visualization by providing temporary hemostasis

Likewise, it is crucial to avoid dilating the stricture, which can obscure estimation of the true margins of the diseased segment resulting in incomplete excision, a common cause of stricture recurrence.

Two angled Debakey vascular clamps are next placed across the urethra, flanking the marked location, and a no. 20 blade is used to transect the entire thickness of the corpus spongiosum and urethra within (Fig. 15.9). We find that the vascular clamps not only facilitate stabilization of the urethra during transection, but also provide hemostasis of the proximal spongiosum, thus preserving visualization. Once the urethra is completely transected, the distal vascular clamp is removed, and the safety wire is carefully pulled out of the distal segment, into the field via the urethrotomy, and secured to the drape to maintain proximal access. We place a distal stay suture (3-0 chromic) into the ventral spongiosal tunica, 1–2 cm distal to the transected edge, perpendicular to the lumen, as this greatly aids in atraumatic manipulation of the distal segment. By gently sounding the distal urethral segment with an 18 Fr catheter, the distal scar is defined and excised. Care is taken to resect back to healthy appearing pink mucosa

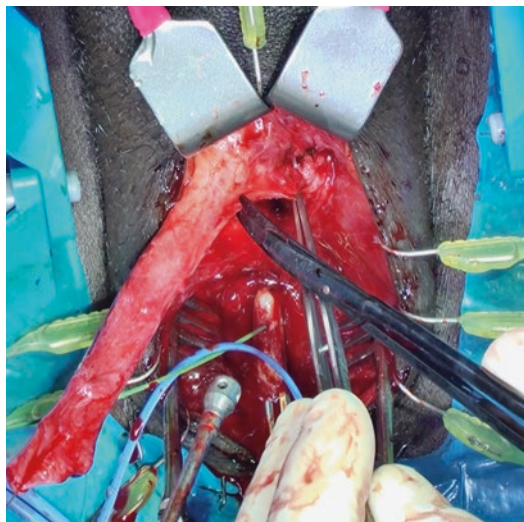


Fig. 15.10 Additional distal bulbar urethral elongation is achieved by sharp mobilization from the remaining scrotal and corporal attachments

with overlying well vascularized spongiosum. It is important to excise all apparent spongiofibrosis, which often appears pale with grossly poor vascularity. The distal segment is spatulated dorsally, and calibrated to 26 Fr or larger with a Bougie-à-Boule. Additional distal mobilization can be performed at this point, further freeing the dorsolateral spongiosal tunica from the corporal tunica above. Gentle countertraction on the previously placed stay suture with an indwelling 18 Fr catheter can facilitate this portion of the dissection (Fig. 15.10).

Attention is next turned proximally. With the previous vascular clamp just proximal to the cut edge, a second vascular clamp is placed below the anticipated proximal margin of the stricture. A fresh no. 20 scalpel blade is used to excise the proximal scar, by cutting between the two clamps, or by removing the distal clamp and using Gerald forceps to lift up on the scarred segment while excising with the scalpel just distal to the remaining vascular clamp. The diseased segment should be grossly excised in its entirety, and additional but judicious excision can be performed after removal of the proximal clamp. To facilitate the process, several 4-0 polyglactin sutures can be placed through the mucosa of the diseased segment, and using a no. 15 scalpel blade, additional meticulous and complete

excision of the fibrotic tissue can be performed while progressively replacing the stay sutures after a portion of the segment has been excised. As this tissue is delicate and often friable secondary to squamous metaplasia, we prefer a “minimal touch” technique whereby we avoid aggressive manipulation or suction which can shear tissue, distort the urethral anatomy, and obscure identification of fibrotic tissue. Frequent irrigation with a syringe and 14 gauge angiocatheter can help to optimize visualization. The proximal-most spongiosal tissue should be spared when possible, as this will preserve antegrade blood flow via the highly vascular spongiosum. The proximal segment is next spatulated ventrally through the mucosa and into the spongiosum, and calibrated to at least 28 Fr with a Bougie-à-Boule (Fig. 15.11). At this point, we perform completion cystourethroscopy to rule out synchronous proximal stricture disease, assess relative external sphincter proximity and degree of coaptation, as well as to characterize findings suggestive of benign prostatic hyperplasia and evaluate for bladder pathology. Alternatively, this step can be performed after placing the proximal anastomotic sutures.

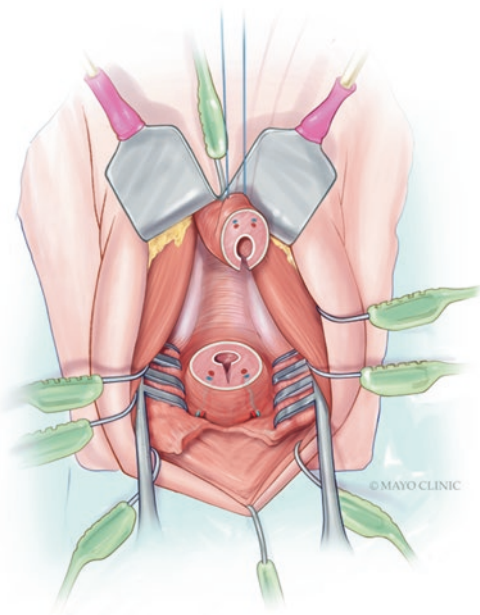


Fig. 15.11 Following complete stricture excision, the distal bulbar segment is spatulated dorsally, and the proximal bulbar segment spatulated ventrally

15.5.1 Anastomosis: Mid to Proximal Bulbar Strictures

Next, attention is directed to the anastomosis. A minimum of eight 4-0 or 5-0 polyglactin or polydioxanone double-armed sutures are placed on the proximal urethral lumen circumferentially, spaced 2–3 mm apart. We prefer a systematic approach to maintain surgeon orientation – 12 sutures spaced evenly around the proximal urethral lumen at positions corresponding to the numbers of a clock face. We begin dorsally (12 o'clock), proceeding in alternating side-to-side fashion around the proximal urethral lumen until the ventral (6 o'clock) suture is placed (Fig. 15.12). Each placed suture further everts to the urethral mucosa and facilitates visualization.

Due to the eccentric dorsal nature of the urethra within the bulbar corpus spongiosum, there is a paucity of spongiosal tissue dorsal to the urethral lumen, in contrast to the robust, highly vascular spongiosum present ventrally. Dorsal anastomotic sutures (9 o'clock to 3 o'clock) are therefore taken full thickness, incorporating the urethral mucosa as well and the thin underlying spongiosum and

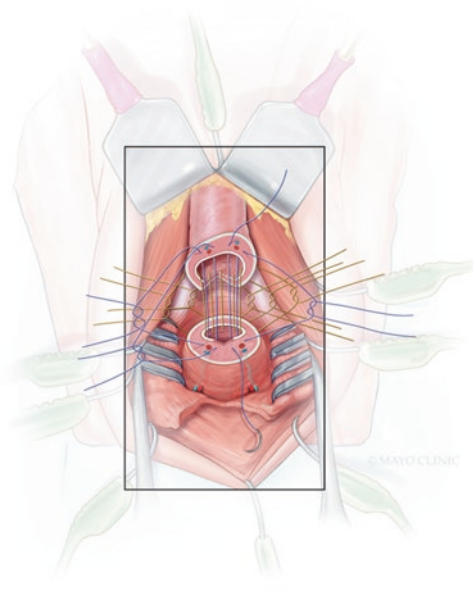


Fig. 15.12 Dorsal anastomotic sutures are placed full thickness, while ventral anastomotic sutures are taken partial thickness to preserve the highly vascularized ventral spongiosum and maximize perfusion across the anastomosis

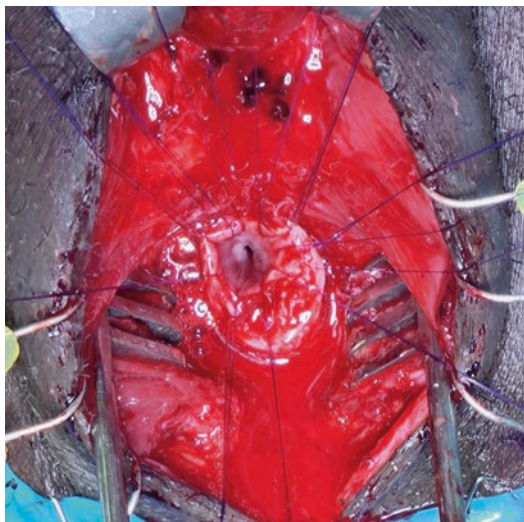


Fig. 15.13 Dorsal full thickness and ventral partial thickness anastomotic sutures placed circumferentially on the proximal bulbar segment

spongiosal tunica. Ventral anastomotic sutures (4 o'clock to 8 o'clock) are partial thickness, incorporating only mucosa and very minimal underlying spongiosum, thereby preserving and reconstituting this highly vascular plexus between the ventral mucosal anastomotic sutures and subsequent running spongioplasty (Fig. 15.13). We use a double-armed anastomotic suture on RB-1 or RB-2 needles to facilitate ease of suture placement in a narrow and deep field. The needle is maintained on the mucosal side of the suture, the suture is tagged with a numbered hemostat corresponding to the suture's location on the clock face, and this is draped over the Lone-Star retractor.

Each of the previously placed proximal sutures (with needles on the mucosal side) are placed through the corresponding locations on the distal urethra, the needle is removed, and the suture retagged with a numbered hemostat that is again draped over the retractor. Just as for the proximal anastomotic sutures, distal sutures placed dorsally are full thickness, and those ventrally are partial thickness. Maintaining a systematic approach, we begin by placing the first distal suture dorsally (12 o'clock proximal suture placed at 6 o'clock position distally) and proceed counterclockwise around the proximal urethra, progressing to the ventral wall. Either just prior to, or immediately after the ventral anastomotic

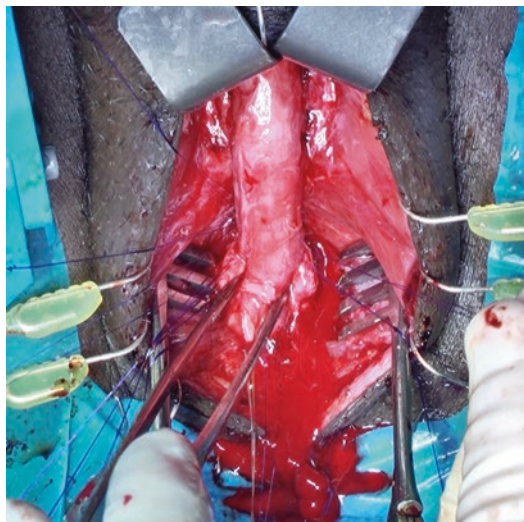


Fig. 15.14 With the final catheter in place, the distal urethra is "parachuted" into position, and the sutures are tied down sequentially, completing the mucosal anastomosis

suture is placed (6 o'clock proximal suture placed at 12 o'clock distally), we place the final 16 Fr clear silicone catheter across the anastomosis. Catheter placement can be cumbersome if delayed beyond this point. After catheter placement, the remaining distal sutures are placed, progressing ventrolaterally around the left side of the anastomosis (right side of surgical field), towards the dorsal wall. The final 1 o'clock proximal suture is placed at the corresponding 5 o'clock position distally, completing anastomotic suture placement (Fig. 15.12).

The distal urethra is approximated to the proximal segment by "parachuting" it into position. This is facilitated by downward traction on the distal urethra segment stay suture while the assistant maintains the tension-free advancement using Debaquey forceps (Fig. 15.14). The sutures are sequentially tied down, in a clockwise direction starting with the last suture thrown (usually 1 o'clock).

15.5.2 Anastomosis: Mid to Distal Bulbar Strictures

For reconstruction of short (<2 cm) mid to distal bulbar urethral lesions a hybrid anastomotic approach can be used, in which the dorsal anastomotic sutures are placed and seated before placing

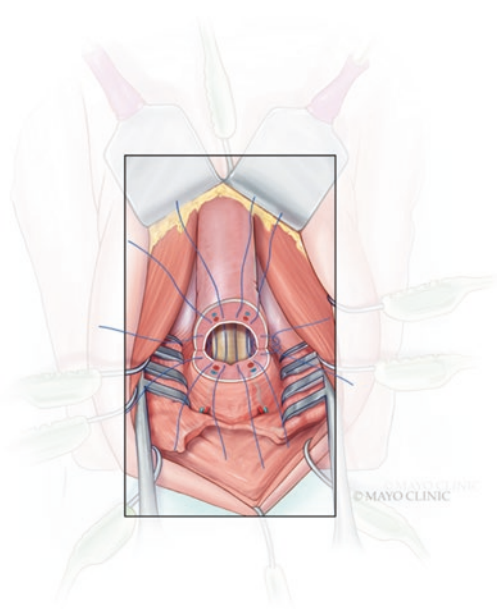


Fig. 15.15 For short (<2 cm) mid to distal bulbar strictures a hybrid anastomotic approach is used to maximize stabilization and efficiency; dorsal anastomotic sutures are placed and tied down, and ventral anastomotic sutures are placed thereafter

the ventral anastomotic sutures. First, proximal bulbar advancement is performed by placing two 4-0 polyglactin stay sutures dorsally, anchoring the proximal dorsal spongiosal tunica to the ventral corporal tunica. This maneuver facilitates a tension free anastomosis, stabilizes the repair, and improves technical efficiency. Beginning dorsally, we place 4–6 full thickness anastomotic sutures sequentially both proximally and distally. After all dorsal sutures are placed, they are tied down consecutively beginning medially and proceeding laterally alternating side-to-side. The final catheter is placed, following which the remaining 4–6 ventral, partial thickness sutures are placed proximally and distally (Fig. 15.15). The ventral sutures are then tied down consecutively.

15.5.3 Spongioplasty and Closure

Spongioplasty is performed in a running fashion with 5-0 polydioxanone suture, taking care to only include tunical edges, avoiding incorpora-

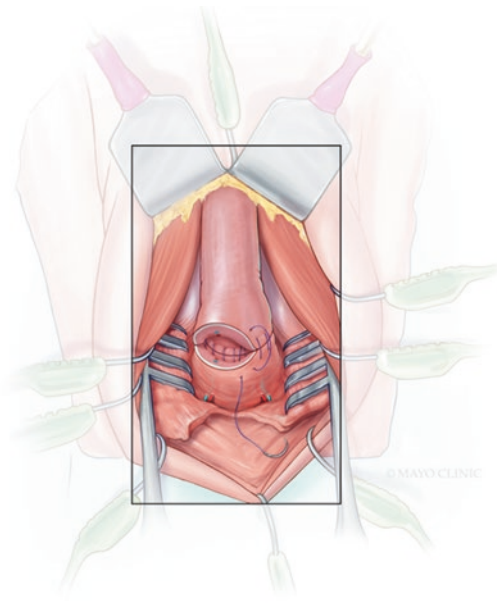


Fig. 15.16 Running spongioplasty, approximating the ventral tunical edges, preserves the underlying, highly vascularized spongiosal tissue, while providing excellent hemostasis

tion of the underlying ventral spongiosum and anastomotic blood supply (Fig. 15.16). This maneuver is crucial as it allows for reconstitution of antegrade bulbar urethral blood flow. The reconstruction and entire surgical field is systematically inspected to ensure hemostasis, and suture ligature or spot electrocautery are used as needed. Bleeding at the urethral meatus, around the urethral catheter, is self-limited and related to incomplete mucosal apposition and spongiosal bleeding at site of anastomosis. Venous bleeding dorsal or dorsolateral to the corpus spongiosum is easily managed with an absorbable hemostatic agent such as oxidized regenerated cellulose (Surgicel Fibrillar, Ethicon, Somerville, NJ, USA) (Fig. 15.17). For routine cases, we do not recommend placing a perineal drain, as this only prolongs convalescence. However, in men with comorbidities requiring early administration of antiplatelet or anticoagulation medications, a closed suction drain can be utilized to reduce hematoma formation.

To minimize high lithotomy positioning related neuromuscular injury, we routinely lower

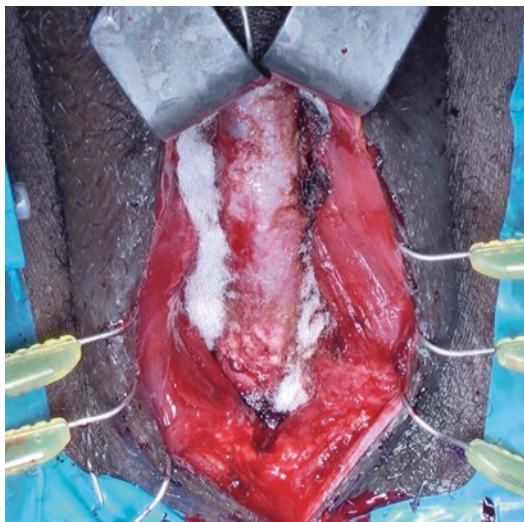


Fig. 15.17 Absorbable hemostatic agent (Surgical Fibrillar) is applied to the bulbar corpus spongiosum dorsolaterally

the patient's legs into a standard to low lithotomy position during closure. Closure begins with reapproximation of the bulbospongiosus muscle with 2-0 poliglycaprone 25 (Monocryl®) suture in running fashion. Colles fascia is then closed with running 2-0 Monocryl, and skin is closed with running 3-0 Monocryl.

Optimal postoperative pain management begins in the operating room. We routinely perform transperineal pudendal nerve blocks using liposomal bupivacaine (20 mL) diluted with 0.25% bupivacaine (30 mL), administered via a 20 gauge needle just medial to the ischial tuberosities bilaterally. The incision is infiltrated with the remaining volume of local anesthetic. In patients with preoperative estimated GFR ≥ 60 mL/min/1.73 m² and without contraindication otherwise, 15 mg of IV ketorolac is administered in the operating room at closure. The catheter is secured to the abdomen with an adhesive Foley stabilization device (StatLock, Bard Medical, Covington, GA, USA), thereby placing the penis in normal anatomic lie, and reducing undue catheter related urethral trauma. The incision is dressed with antibiotic ointment, over which bulky fluffed gauze is

placed. The bolster of gauze is then compressed against the perineum and scrotum with an athletic supporter.

15.6 Postoperative Management

After a short observation period to ensure satisfactory recovery from general anesthesia and adequate pain control with an oral medication regimen, the majority of men are dismissed to the ambulatory setting on the day of surgery. Though uncommon, it is important to identify patients who may benefit from overnight observation in the hospital, including those with poor social support, extensive comorbidities, advanced age, or unable to immediately understand postoperative instructions and recommendations. For the first 48 hours after surgery, patients are advised to utilize scheduled, alternating acetaminophen and ibuprofen, such that one of the two medications is taken every 3 hours in alternating fashion; beyond 48 hours after surgery, patients are directed to take these on an as-needed basis. A scheduled long-acting anticholinergic is prescribed for bladder spasms associated with the indwelling urinary catheter, which may forcefully expel urine around the catheter and repair. A petroleum-based ointment is provided for catheter-associated meatal irritation. A small quantity of narcotic pain medication (oxycodone, 5 mg tablets) is prescribed for breakthrough pain. In our experience, utilizing the non-opioid pain management protocol outlined above, we have found that opioid naïve men will uncommonly utilize greater than 5 tablets of oxycodone after outpatient bulbar urethroplasty. Patients are encouraged to take stool softeners to prevent constipation, which is common and can be problematic after perineal surgery. Activity restrictions aim to minimize patient discomfort, and reduce the risk of catheter dislodgement and perineal hematoma. As such, patients are advised to limit activities to those of daily living. Light walking is encouraged beginning immediately postoperatively. More aggressive activity restriction, including periods of bedrest, are unnecessary.

15.7 Catheter Duration and Postoperative Imaging

The postoperative urethral catheter enables a period of anastomotic healing with uninterrupted mucosal coaptation by diverting urine away from the anastomosis. Following uncomplicated anastomotic urethroplasty, satisfactory healing is achieved in most by 3 weeks, at which point we prefer catheter removal and voiding trial without postoperative imaging. Initial postoperative VCUG to assess anastomotic integrity at two to three weeks postoperatively typically demonstrates an intact repair without contrast extravasation (Fig. 15.18) [25, 26]. On retrospective review of 210 men undergoing anastomotic urethroplasty, we found that none of the 59 men who underwent bulbar EPA (mean stricture length 2.2 cm) had contrast extravasation on initial postoperative VCUG performed at a mean 24 days postoperatively [25]. In our practice, we reserve postoperative VCUG imaging for those with tenuous or lengthy repairs and risk factors for healing related complications. Though rare, when extravasation is present on initial postoperative VCUG it can be effectively managed with gentle replacement of a 14 Fr catheter and repeat imaging evaluation in one week. When appropriately managed, the small

subset of men with extravasation on initial VCUG do not appear to be at increased risk of complications such as infection, fistula, or stricture recurrence [25]. We have generally abandoned the pericatheter RUG, as pressures generated with this technique are typically below physiologic voiding urethral pressures, limiting its sensitivity for anastomotic urinary extravasation.

15.8 Clinical Outcomes

15.8.1 Efficacy

Excision and primary anastomosis in appropriately selected men with bulbar urethral stricture disease is highly efficacious, with success rates at experienced centers exceeding 90%. Table 15.1 demonstrates the results from 19 retrospective series over more than four decades, representing greater than 1500 patients. Recognizing variability in patient selection, follow up duration and strategy, and definition of failure, the composite reported level of success was 93.1%. The largest reported experience in the literature included 260 patients, with only 3 failures [22]. This 98.8% success rate at a mean follow up of 50 months highlights the long-term durability of anastomotic urethroplasty.

15.8.2 Complications

Anastomotic bulbar urethroplasty is a relatively low risk operation, and major postoperative complications are uncommon. Positioning-related complications such as lower extremity neuropraxia, venous thromboembolism, rhabdomyolysis, and compartment syndrome are rare [20]. These risks can be reduced by limiting the duration of exaggerated lithotomy positioning (<5 hours), and ensuring the legs and bony prominences are adequately positioned and padded. With careful attention to patient positioning and limiting duration of high lithotomy position, lower extremity neuropraxia occurs in less than 1% of cases and is typically self-limited [27]. Measures to prevent postoperative venous thromboembolism include



Fig. 15.18 Normal VCUG shown three weeks after anastomotic bulbar urethroplasty

Table 15.1 Outcomes of transection and anastomosis for bulbar urethral stricture disease

First author	Year published	No. patients	Follow-up (months)	Rate of success (%)	Definition of failure
Azoury et al. [43]	1976	13	– (Minimum 12 months)	92	Abnormal retrograde urethrogram Obstructive symptoms Urethral sound impassable
Panagakos et al. [44]	1978	42	–	95	Restricture requiring intervention
Jakse et al. [45]	1986	55	45 ^a	92.7	Flow rate <10 mL/s Dilation on voiding urethrography +/- UTI
Lindell et al. [46]	1993	18	–	95.9	–
Martinez-Piñeiro et al. [47]	1997	81	44.4 ^a	84 ^a	Stricture recurrence needing further surgical intervention
Micheli et al. [48]	2002	64	60 ^a	93 ^a	Symptoms of obstruction Flow <15 mL/s and cystourethrography showing no signs of recurrent stenosis
Santucci et al. [26]	2002	168	72	95	Need for subsequent dilation, internal urethrotomy or urethroplasty Recurrent obstructive voiding symptoms
Lewis et al. [49]	2002	31	– (Minimum 12 months)	97	Abnormal retrograde urethrogram Obstructive symptoms Urethral sound impassable
Andrich et al. [40]	2003	34	– (Total 10 year)	87	Symptoms and investigations showing the presence of a recurrent stricture
Kessler et al. [50]	2003	23	46	86	Restricture on urethrogram or endoscopy Flow rate <15 mL/s Recurrent UTI
Morey et al. [12]	2006	22	22.1	91	Non-validated questionnaire
Eltahawy et al. [22]	2007	257	50.2	98.8	Need for any intervention postop except for scheduled endoscopy
Elgammal et al. [51]	2009	25	– (Total 3 year)	96	Symptoms of infravesical obstruction Qmax <15 mL/s PVR persistently >50 mL Poor caliber on ascending urethrography
Gupta et al. [52]	2009	24	26.7	100	Obstructive symptoms Incontinence Postop intervention
Terlecki et al. [11]	2010	72	17	98.6	Need for any postop intervention
Lumen et al. [53]	2010	62	39	90.3	Need for subsequent instrumentation or reoperation
Granieri et al. [54]	2014	202	16.9	94.6	Need for an additional surgical procedure or dilation
Chapman et al. [17]	2017	165	65.4 ^a	96.7	Recurrent symptoms with restricture <16 Fr on cystoscopy
Barbagli et al. [55]	2018	213	181	85.9	Need for any postop intervention including dilation
<i>Total</i>		<i>1571</i>		<i>93.1</i>	

^aReported for all study patients, not specific to cohort undergoing bulbar EPA

intraoperative lower extremity sequential compression devices, early postoperative ambulation, and risk based assessment of need for chemoprophylaxis.

Bothersome scrotal edema and ecchymosis are common during the first one to two weeks after bulbar urethroplasty as a result of blood products expanding from the perineum along fascial planes into the dependent scrotum. Intraoperatively, the application of hemostatic agents (Surgicel Fibrillar) are a useful adjunct to control venous oozing. We have also found that scrotal support with compressive undergarments mitigates swelling and patient discomfort. In contrast, large perineoscrotal hematomas are rare after bulbar EPA (<2%) [27]. De novo lower urinary tract symptoms including urinary urgency may occur in up to 11% of patients, but typically improves within 3 months postoperatively; if persistent or progressive thereafter, should prompt further evaluation [27–29].

Overall, infectious complications are rare and occur in less than 6% of cases [27, 28]. Symptomatic urinary tract infection can occur in less than 5% of cases with greatest risk during postoperative urethral catheterization [27–30]. While many surgeons maintain patients on prophylactic antibiotics until catheter removal, a single dose of therapeutic antibiotics, such as a fluoroquinolone or trimethoprim-sulfamethoxazole administered just prior to catheter removal, is likely sufficient to prevent infection [30]. Wound related complications may occur in up to 1 in 5 patients with the greatest independent risk factor being a lambda perineal incision [21]. To avoid this risk, we recommend the use of a standard midline perineal incision for the majority of cases. While persistent urethrocutaneous fistula is extremely rare, it is often the cause of patient related factors of impaired healing or metachronous distal stricture disease. After addressing contributing factors, we recommend urethral catheter removal, suprapubic tube placement and delayed repair.

15.8.3 Sexual Dysfunction

Sexual dysfunction after all anterior urethroplasty techniques, encompassing erectile dysfunction (including decreased glans engorgement),

ejaculatory dysfunction, and/or chordee, has been well described. Dissection near the urethral bulb risks injury to the cavernous neurovascular bundles, which lie dorsolaterally after exiting the urogenital diaphragm lateral to the membranous urethra on their way to innervating the erectile bodies [31, 32]. The rate of transient, de novo erectile dysfunction after anterior urethroplasty is variably reported (1–38%), with one recent large multi-institutional series reporting a 14% rate of de novo sexual dysfunction after transecting anastomotic urethroplasty [33]. For most men, this is transient in nature, with patients returning to preoperative levels of function by 6–12 months postoperatively [32, 34–36]. The rate of de novo and persistent erectile dysfunction after bulbar urethroplasty is approximately 1%, and is likely related to degree of preoperative erectile function [35, 37].

Ejaculatory dysfunction, including decreased force of ejaculation, may be related to neuromuscular compromise from bulbospongiosus muscle transection and unnecessary lateral dissection. Meticulous, sharp midline dissection and division of the bulbospongiosus, combined with careful reapproximation following reconstruction appears to reduce this risk. While some have advocated for a bulbospongiosus muscle-sparing approach, in our experience this is unnecessary [38]. Clinically significant chordee can be nearly eliminated by avoiding bulbar EPA in men with distal bulbar strictures greater than 2 cm in length, particularly in men with shorter than average SPL (<14 cm), as well as by complete distal bulbar urethral mobilization to the level of the penoscrotal junction [12].

15.8.4 Recurrent Stricture

An uncommon but critical delayed complication after bulbar urethral transection and anastomosis is stricture recurrence. This tends to occur in fewer than 10% of men. Ischemia and subsequent anastomotic fibrosis may be due to patient factors (previous surgeries, diabetes, tobacco use, peripheral vascular disease, etc.), or technical factors such as undue anastomotic tension or incomplete excision of the diseased segment. Clinically sig-

nificant urethral stricture recurrences most often present with progressive obstructive voiding symptoms prompting diagnostic evaluation (office cystourethroscopy and/or RUG) [39]. Andrich and colleagues evaluated re-stricture rates over time in 34 men who underwent excision and primary anastomosis for bulbar urethral strictures, and found 1, 5, 10 and 15-year restructure rates were 7%, 12%, 13% and 14%, respectively [40]. This long-term data suggest that most all symptomatic recurrences occur within five years postoperatively and a large proportion occur within the first year. Early stricture recurrences are often the result of incomplete stricture excision or undue tension on the anastomosis.

For thin, short (<1 cm) recurrences, a single salvage endoscopic internal urethrotomy has been associated with excellent results. Kahokehr and colleagues found that recurrent stricture after bulbar EPA, managed with a single salvage endoscopic procedure, was associated with 90% stricture-free rate at mean follow-up of 26 months [39]. For lengthy, or dense recurrences endoscopic management following anastomotic urethroplasty has demonstrated unfavorable outcomes with success rates of <15% [41]. These treatment refractory strictures are likely the result of ischemia induced fibrosis – a condition for which salvage urethroplasty should be offered. Reoperative EPA in this setting is associated with a success rate as high as 95%, comparable to that of first time anastomotic urethroplasty [42].

15.9 Conclusions

Stricture excision and primary anastomosis is the most straightforward and effective surgical approach for well-selected bulbar urethral strictures. After resecting all fibrotic urethra, a wide mucosa-to-mucosa tension-free end-to-end anastomosis is hand sewn to restore urethral continuity. This technique is ideally suited for bulbar strictures 1–3 cm in length, but can be utilized in select cases with proximal bulbar strictures up to 5 cm in length. Short term complications are rare and consist primarily of hematoma or infection of the incision site, and long term rates of restenosis are less than 10%.

Key Summary Points

- Complete stricture excision and primary end-to-end is the most durable and effective reconstructive option for appropriate bulbar urethra strictures
- The bulbar urethra is exposed via wide perineal dissection, and is meticulously mobilized, using its natural elasticity to facilitate urethral elongation
- The stricture is completely excised, and a tension-free spongiosal sparing 2-layer anastomosis is performed
- This technique can be applied to strictures less than 2 cm at any location within the bulbar urethra, and to strictures up to 5 cm in the mid to proximal bulbar urethra
- Complications are uncommon and generally minor
- This technique is well tolerated, with long-term cure rate >90%

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Substitution Urethroplasty for Bulbar Urethral Strictures

16

Akio Horiguchi and Masayuki Shinch

16.1 Background

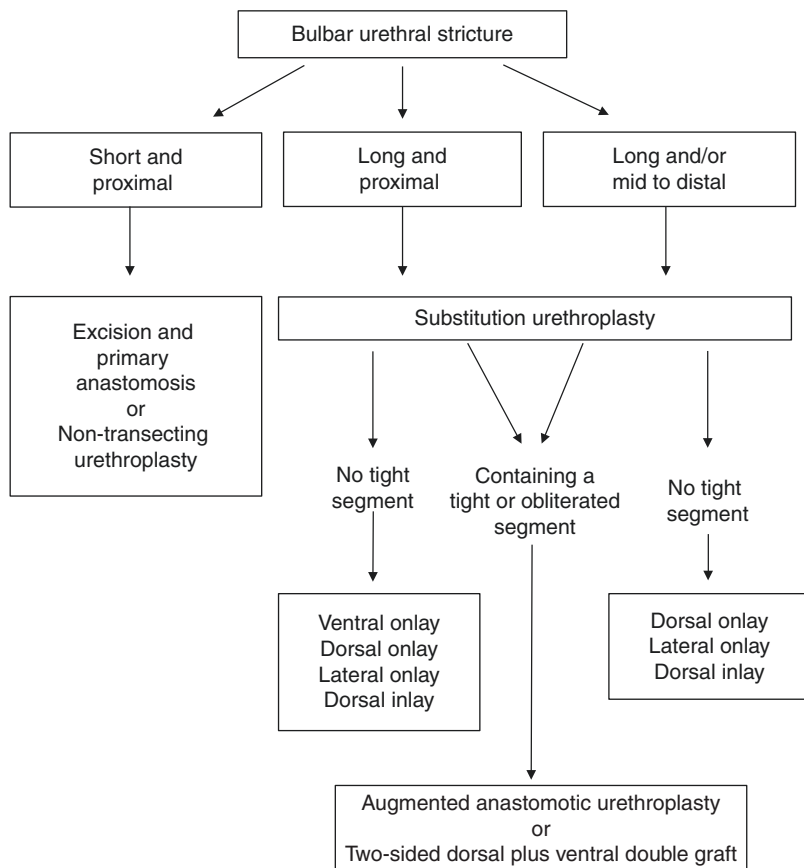
Male anterior urethral stricture is one of the oldest urologic disorders and has an estimated prevalence of 0.6% in susceptible populations [1, 2]. Anterior urethral stricture, a fibrosis of the epithelial tissue and corpus spongiosum resulting in stenosis of the urethral lumen, is a relatively common urologic problem with various etiologies—typically including external trauma, iatrogenic factors, and genital lichen sclerosus (LS)—that decreases the urinary stream and adversely impacts not only patient-reported quality of life but also overall health status [3]. The bulbar urethra is the most common site of anterior urethral stricture [4, 5] and its etiology is idiopathic in about 40% of cases, iatrogenic in 35%, traumatic in 15%, and inflammatory in 10% [3].

The surgical management of bulbar urethral stricture has changed dramatically in the last several decades [6]. The long-term outcome of transurethral managements such as dilation and urethrotomy that have been widely used has been found to be poor, and urethroplasty has become standard treatment for urethral stricture [7]. The types of urethroplasty for bulbar urethral strictures are mainly categorized into two groups (Fig. 16.1). One is excision and primary

anastomosis (EPA), which consists of resecting all fibrotic urethral segments and tension-free re-approximation of the proximal and distal urethral ends [8]. This group also includes non-transecting repair, which was described as an alternative to an EPA for very short bulbar strictures with minimal spongiofibrosis in order to preserve bulbar arteries and avoid sexual dysfunction resulting from corpus spongiosum transection [9–11]. The other group is substitution urethroplasty in which the fibrotic urethral segment is augmented or replaced by using grafts or flaps [12] and has become the gold standard procedure for urethral strictures that are not suitable for EPA. Although EPA is the preferred method of urethral reconstruction whenever possible because of its high success rate and durability compared to substitution urethroplasty [13–15], the length and location of the stricture and the size and elasticity of the urethral segment limit the use of EPA [16–18]. The amount of length that can be gained will depend on the anatomy of the individual male patient: the size of his penis and urethra, or particularly, the length and elasticity of the distal urethral segment [12]. Stricture in the proximal bulbar urethra can be bridged because the bulbar urethra can be fully elongated by full mobilization of it and separating the corpora can straighten the natural curve of the bulbar urethra and shorten its course [18]. For a longer stricture, however, excising the entire stricture and making an anastomosis

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Fig. 16.1 A flowchart of selecting the type of urethroplasty for bulbar urethral stricture



without tension is impossible. When the stricture is in the more distal bulbar urethra, the gap that can be bridged is shorter and anastomotic urethroplasty is applicable only for short (probably within 1 cm) strictures because mobilizing the bulbar urethra beyond the region distal to the penoscrotal junction has a risk of causing chordee [18]. Moreover, some experts favor substitution urethroplasty even for bulbar strictures that can be managed by EPA because EPA can cause sexual dysfunction such as ejaculatory dysfunction, decreased glans sensitivity, and penile chordee and can decrease penile length [19–21]. Substitution urethroplasty is therefore the procedure of choice for a long stricture in the proximal bulbar urethra or a stricture of any length located anywhere from the distal bulbar urethra and for strictures in patients who worry about sexual dysfunction.

16.2 Advantage of Buccal Mucosa as a Urethral Substitute

A number of different tissue types—including penile skin, scrotal skin, extragenital skin, bladder mucosa, intestinal mucosa, and oral mucosa—have been used as urethral substitutes [22–27]. Traditionally, penile skin as a pedicled flap or as a free graft had been considered the most reliable material for reconstruction of urethral strictures and until several decades ago had been the most popular material for anterior urethroplasty [28–30]. However, penile skin has gradually been replaced by buccal mucosa grafts (BMGs) because of their advantageous histological properties and superior handling characteristics [12, 31, 32]. It has been shown that there was a much higher morbidity with penile skin flaps than with BMGs—including penile hematoma,

skin necrosis, and fistula formation—and that the flap procedure was also technically more complex and less likely preferred by patients [33]. In addition, tunneling a skin flap through the scrotum is required in bulbar urethroplasty, which may tether the penis during erection [34]. Although penile skin flaps still have an important role in the armamentarium in anterior urethroplasty, their use in bulbar urethroplasty has become limited to exceptional cases such as long segmental strictures [35]. Penile skin has also been the mainstay of grafting material until buccal mucosal grafts became popularized. Compared with the preparation of a penile skin flap, harvesting a penile skin graft is technically simple and has lower complication rates [36]. However, recent studies show substitution urethroplasty using penile skin graft is inferior to that of using BMG. Lumen et al. performed a meta-analysis comparing outcomes of penile skin graft urethroplasty and BMG urethroplasty and found a slightly worse outcome in the penile skin graft group: 81.8% success versus 85.9% ($p = 0.01$) [37]. Barbagli also reported the long-term success rate of 359 patients who underwent one-stage anterior substitution urethroplasty with a minimum of 6 years follow-up. At 6 years oral mucosa (including buccal mucosa) showed a greater failure-free survival rate (78.0%) than penile skin (62%) and the only significant predictor of successful urethroplasty was the substitute tissue type [22]. Granieri et al. reported that changing the routine use of penile skin for augmented anastomotic urethroplasty to the routine use of buccal mucosa improved the recurrence rate (from 21.6% with penile skin to 5.8% with buccal mucosa) [32]. In addition, penile skin has to be avoided in the reconstruction of anterior urethral stricture associated with LS because it may become diseased and associated with a very high long-term failure rate [38]. Based on this, BMG has become the best urethral substitute among various tissues.

El-Kassaby first reported experience with adults undergoing urethroplasty (eight patients with bulbar urethral strictures) using BMG in 1993 [39]. Morey and McAninch thereafter showed a new technique for harvesting buccal mucosa and its use was popularized [40]. Buccal

mucosa has several unique characteristics. The environment of the mouth ensures that buccal mucosa is highly resistant to infection and trauma. The epithelial layer is thick, making the graft easy to harvest and handle. It takes readily and inoculates early because it has a thin lamina propria and dense panlamellar vascular plexus. It also has a privileged immunology, and preclinical work suggests that it shows fibroblast behavior resulting in less fibrosis than skin and a profile quite different from that of skin. Buccal mucosa is an appropriate urethral substitute for strictures associated with LS [38]. Oral mucosa graft can be harvested not only from the inside of a cheek but also from the lower side of the tongue (lingual mucosa) or the inside of the lip (labial mucosa). Although lingual mucosa has characteristics similar to those of buccal mucosa and appears to be as efficacious as buccal mucosa [26], a lingual mucosa graft is typically not as wide as a buccal mucosa graft and is flimsier [34]. Lingual mucosa might therefore be better to use in patients with a short stricture requiring only a small amount of grafts, in patients with a lengthy stricture requiring additional grafts with a tissue other than buccal mucosa, and in patients for salvage urethroplasty whose buccal mucosa has already been harvested bilaterally. Labial mucosa can be managed in a similar way but is thinner and more difficult to handle. In addition, lip contracture is a devastating complication reported in 3–5% of patients after lip graft harvest [41–43]. The risk of numbness and deformity after lip grafts harvest is also high, and it is best to avoid use of labial mucosa grafts when possible.

Techniques used for harvesting buccal mucosa grafts are described elsewhere [44]. Nasal intubation is not mandatory but it is helpful for surgeons unfamiliar with this technique. The graft is designed in an ovoid shape for one-stage urethroplasty to adjust to the shape of the urethral opening or is designed in a rectangular shape for staged urethroplasty requiring a larger graft. It has to be kept in mind to harvest the graft about 1.5 cm from the parotid duct (Stensen duct) to prevent injury [44]. Another concern is whether or not the wound at the donor site has to be closed. Some studies have suggested that

the incidence of postoperative complications in patients who undergo BMG harvesting is mainly influenced by the closure vs. non-closure of the donor site [43, 45]. Barbagli reported a survey of 553 patients revealing that 53.2% of them experienced no postoperative pain and 98.2% would undergo the surgery again. They concluded that harvesting from a single cheek with closure of the donor site was a safe procedure with high patient satisfaction [44]. Soave and colleagues recently conducted a randomized trial to find out whether or not closure of the donor site after harvesting buccal mucosa is necessary and found that non-closure of the resulting mucosal defect is not inferior to closure in terms of the intensity and nature of the consequent pain experienced by patients [46]. Ultimately, the decision to close the donor site primarily or leave it open is at the discretion of the surgeon.

Although buccal mucosa is a convenient source of donor tissue with many characteristics of the ideal urethral graft, harvesting BMG is associated with donor site complications [47]. To overcome the risk of comorbidity, Barbagli et al. developed tissue-engineered oral mucosa graft from tiny oral mucosa biopsy samples taken from the cheek (MukoCell® graft) and used it in one-stage substitution urethroplasty in 38 patients with anterior urethral stricture (three penile, 29 bulbar, and six penobulbar strictures) with a median stricture length of 5 cm, demonstrating with a median follow-up of 55 months a success rate comparable with that of conventional substitution oral mucosa urethroplasty [48]. Tissue-engineered graft is an emerging frontier of urethral reconstruction and holds substantial promise.

16.3 Preoperative Evaluation and Management

Accurate determination of the characteristics of a stricture is the first step in a successful urethroplasty. Prior to the examination, it is necessary to stabilize the stricture by “urethral rest”, especially in patients with a history of repeated urethral manipulations. “Urethral rest” is the

concept of avoiding manipulation of the urethra for at least 3 months and allowing the urethral scar to mature before definitive urethroplasty [49]. For those with a high level of concern for urinary retention (rapid symptom recurrence after prior urethral dilation and/or increased difficulty with self-dilation), suprapubic tube (SPT) placement as soon as possible is recommended. Urethral rest promotes identification of severely fibrotic segments and facilitates proper selection of the urethroplasty technique [49]. A period of urethral rest resulted in more frequent stricture obliteration and about half of the cases was associated with a change in the planned operation approach [50].

A retrograde urethrogram (RUG) is the standard investigation of anterior urethral strictures, and a consecutive ascending and voiding cystourethrogram should also be carried out in order to better define the proximal limit of the stricture and assess the external sphincter complex and bladder neck [51]. However, these radiographic studies often underestimate stricture length because they are performed in an oblique position in relation to the anteroposterior x-ray beam, resulting in a shorter projected view of the stricture [52]. For very tight strictures, chronic high-pressure voiding dilates the proximal segment and makes the stricture appear to be shorter than it really is. Urethral surgeons should keep in mind that a RUG’s ability to accurately reveal stricture length and location and the extent of periurethral disease is limited. Endoscopy may be useful for visualizing the mucosa around the stricture. Pink mucosa is healthy but pale grey mucosa is a sign of submucosal fibrosis that needs to be reconstructed. This evaluation may be particularly important in patients with previous urethroplasty or those managed with urethrotomy or dilation. Urethral ultrasound can be used as an adjunct to RUG and may be more sensitive than RUG in the assessment of stricture length and the degree of spongiositis [53], but the clinical relevance of this possibly higher sensitivity is unclear [51].

The approach to bulbar urethral stricture repair is usually guided by the stricture’s appearance on retrograde urethrography, but intraoperative findings dictate the final operative

plan. In all cases, intraoperative assessment and localization are the final determinants of how a stricture is reconstructed because they yield the most information [54].

16.4 Urethroplasty Categories and Selection of Urethroplasty Type

Stricture characteristics that influence the type of reconstruction include stricture length, anatomic position, degree of spongiositis, etiology, and previous treatment [8, 12, 38] (Fig. 16.1). The bulbar urethra lies between the penoscrotal junction and membranous urethra and is subdivided into two parts, proximal and distal. The proximal bulbar urethra is defined as the segment within 5 cm of the membranous urethra and the distal urethra is defined as the adjoining segment extending to the penoscrotal junction [18]. The bulbar urethra is surrounded by the thickest portion of the corpus spongiosum and is eccentrically placed toward the dorsum. Thus the surrounding tissues of the corpus spongiosum are dorsally thin and ventrally thick [12]. The reconstructive methods used in the distal and proximal bulbar urethra differ markedly because of the different thicknesses and elasticities of the associated spongiosum tissue.

Surgical procedures of substitution urethroplasty are categorized into one-stage and staged procedures and almost all bulbar strictures can be repaired by one-stage urethroplasty. There are three potential options for a one-stage procedure: onlay augmentation (incise the stricture and carry out a patch augmentation), augmented anastomosis (excise the stricture and restore a roof or floor strip of native urethra augmented by a patch), and tube augmentation (excise the stricture and put in a circumferential patch) [12]. One-stage tube augmentation has a high risk of stricture recurrence regardless of the stricture location and should be avoided [12, 38]. Onlay graft urethroplasty is the method used widely to repair bulbar urethral strictures. Ventral and dorsal onlay urethroplasties are the most popular types of substitution urethroplasty, and the choice of ventral or

dorsal remains a matter of debate [12, 55]. Two other options are a dorsal inlay with ventral sagittal urethrotomy without urethral dissection [56] and a lateral onlay procedure with only one-sided urethral dissection [57, 58]. To date, there is no difference in success rates among the grafting positions [12, 55, 59–63]. When a bulbar urethral stricture has an obliterative or nearly obliterative segment, what should be used is a combination of EPA and onlay augmentation called augmented anastomotic urethroplasty [64], and an onlay augmentation using two grafts applied both dorsally and ventrally to obtain an adequate lumen without transecting the urethra (two-sided dorsal plus ventral onlay urethroplasty) [65–67].

Bulbar urethroplasties are usually performed in a social lithotomy position with a midline perineal incision or lambda incision, depending on the surgeon's preference. Substitution bulbar urethroplasty using BMG is discussed below.

16.4.1 Ventral Onlay

Ventral onlay for bulbar urethral strictures was first described by Morey and McAninch in 1996 [68]. Once the stricture is located, a midline sagittal incision is made through the ventral spongiosum, leaving the surrounding supportive structure intact. The graft is then sewn directly to the edges of the urethrotomy to augment the urethral lumen, and then the corpus spongiosum is closed over the graft to provide a well-vascularized bed (Fig. 16.2). The advantages of the ventral onlay procedure include limited urethral mobilization with preservation of perforating arteries and shorter operative time and easier technique compared to the dorsal onlay procedure. In obese patients and patients with proximal bulbar stricture, dorsal graft placements are typically more difficult to sew in a deep and proximal wound. In patients who have undergone repeated DVIUs or urethroplasties, the urethral lumen may be adherent and firmly fixed to the tunica albuginea and urethral mobilization from the corpora cavernosa is difficult. In these patients the use of a ventral onlay procedure is preferable. Ventral onlay urethroplasty, however, is usually performed

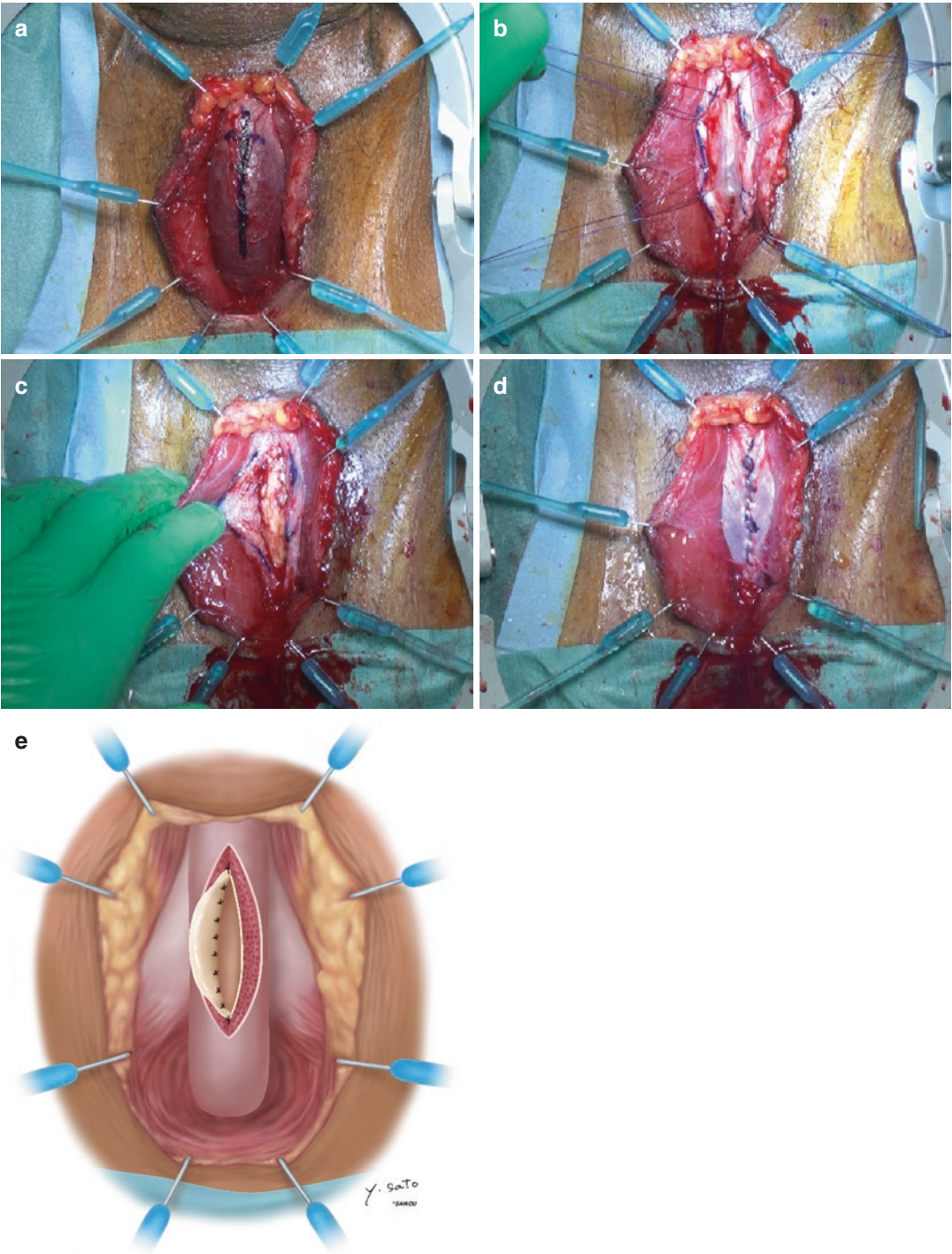


Fig. 16.2 Ventral onlay. (a) The corpus spongiosum is opened along its ventral surface and (b) the urethral lumen is fully exposed, extending the urethrotomy distally and proxi-

mally to the stenosis. (c) The graft is sutured to the edge of the urethral mucosa plate. (d) The spongiosum tissue is closed over the graft. (e) Schematic image of ventral onlay

only for midbulbar and proximal bulbar strictures because only in those areas is the bulb wide enough for adequate spongioplasty (Fig. 16.1). Furthermore, ventral onlay is not suitable for traumatic bulbar urethral strictures because a severely scarred corpus spongiosum does not work as a vascularized graft bed. Because the ventral spongiosum is more robust it bleeds vigorously, compromising visualization and making graft placement challenging. Although ventral spongiosum tissue is thick and its blood supply is rich, it is not particularly firm compared with the strength of the underlying corporal bodies. This fragility of the ventral spongiosum may increase the risk of graft sacculation.

Regarding surgical outcome, a recent review including 563 patients in 24 studies reported that with an average follow-up of 34.3 months the overall average success rate of ventral onlay bulbar urethroplasty was 88.8% [55]. BMG was used as substitute urethra in most of the patients evaluated in that review. Barbagli et al. reported that in a retrospective study of 214 patients with bulbar stricture (median stricture length 4.4 cm) who underwent ventral onlay urethroplasty using only BMG in a single high-volume center, with a median follow-up of 54 months the success rate was 85.5% [69].

16.4.2 Dorsal Onlay

The dorsal onlay urethroplasty pioneered by Barbagli [70] involves mobilizing the bulbar urethra and rotating it 180 ° so the urethrotomy can be made on the dorsal aspect of the strictured segment. A graft is then quilted to the underlying tunica albuginea of the corpora cavernosa both along the edges of the graft and across the face of the graft, which helps prevent graft contracture and graft elevation due to an underlying hematoma. The dorsally fixed buccal graft is then sutured to both edges of the urethrotomy with the urethra rotated back to its original position to cover the grafted area (Fig. 16.3). Among the advantages of the dorsal onlay procedure

is a more stable and reliably well-vascularized graft bed and less possibility of sacculation [60]. The corpus spongiosum in the bulbar urethra is thicker ventrally and thinner dorsally. Furthermore, the urethral lumen is located dorsally rather than centrally; thus, a dorsal incision may be more likely to preserve the residual blood supply to the spongiosum tissue and to result in less intraoperative blood loss and less possibility of impairing visualization during urethral exposure and graft placement. The dorsal approach to graft placement may also be preferred because it is the most versatile irrespective of the location of the corpus spongiosum and has been successfully used in all parts of the bulbar urethra (Fig. 16.1). The dorsal onlay procedure is preferable in the distal bulbar urethra because the bulb is not wide enough for a spongioplasty adequate for ventral onlay and attaching the graft to the tunica albuginea of the corpora cavernosa is easier in the distal bulbar urethra. Another advantage of the dorsal onlay procedure is its excellent adaptability to other procedures. When complete or nearly complete obliteration of the urethra makes a single augmentation graft impossible, one can enhance the dorsal graft with either an augmented anastomotic reconstruction [64] or a combination of ventral inlay graft [71]. Disadvantages of the dorsal onlay procedure are that circumferential mobilization disrupts the surrounding microvasculature and visualization of the proximal urethra is challenging.

A recent review described the success rate of 35 studies of the dorsal onlay bulbar urethroplasty in a total of 934 patients. The average success rate, with an average follow-up of 42.2 months, was 88.4%, which is almost the same as the success rate of ventral onlay bulbar urethroplasty [55]. Subsequent retrospective analysis also showed similar success rates of dorsal onlay and ventral onlay procedures for bulbar urethral stricture [60–62]. A prospective randomized study comparing dorsal onlay and ventral onlay procedures in BMG urethroplasty for bulbar stricture showed comparable results (92.5% for dorsal onlay and 90% for ventral onlay) [63].

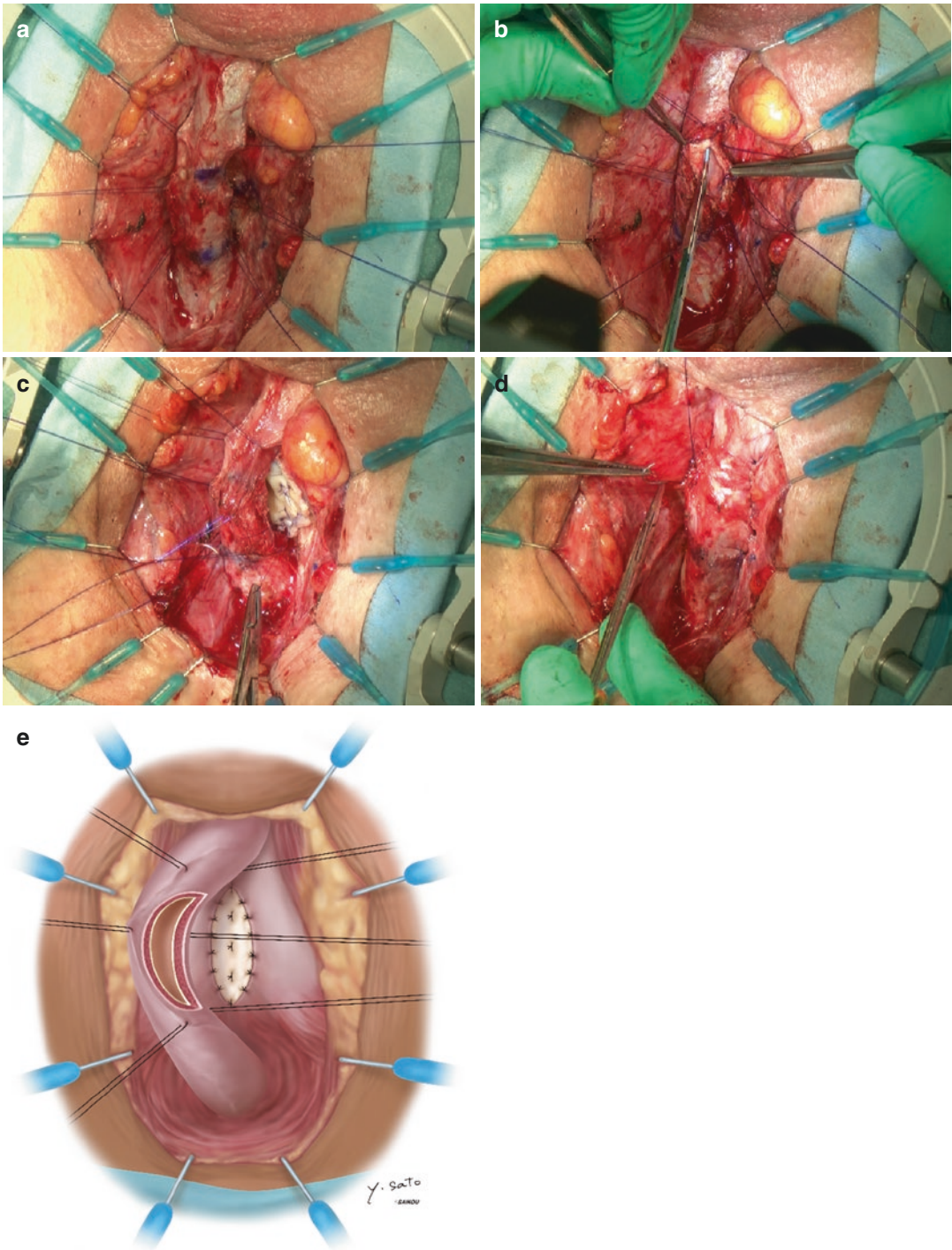


Fig. 16.3 Dorsal onlay. **(a)** The bulbar urethra is circumferentially mobilized and rotated. **(b)** The dorsal urethral surface is incised along the midline to expose the entire stricture. **(c)** The graft is spread, fixed over the corpora

cavernosa. **(d)** The bulbar urethra is rotated back and the margin of the graft is sutured to the margin of the urethral mucosal plate. **(e)** Schematic image of dorsal onlay

16.4.3 Lateral Onlay

The lateral graft placement described by Barbagli is an amalgam of the ventral and dorsal approaches [57]. Kulkarni et al. subsequently proposed a one-sided dorsolateral graft urethroplasty that, eliminating the need for full circumferential mobilization of the urethra and preserving the lateral vascular and nerve supply to the urethra and establishing secure dorsal grafting, is a minimally invasive alternative to conventional dorsal onlay urethroplasty [58]. The urethra is dissected from the corpora cavernosa only along one side, starting from the distal tract where bulbospongiosus muscles are absent, and is partially rotated leaving the other side attached to the corpora cavernosa, and leaving the bulbospongiosum muscle and the central tendon of the perineum intact (Fig. 16.4). The distal extent of the stricture is identified, the dorsolateral urethral surface incised along the midline, and the urethral lumen exposed. The stricture is then incised along its entire length by extending the urethrotomy both distally and proximally into the healthy urethra. The buccal mucosa graft is spread fixed over the tunica albuginea and sutured to the margin of the urethral mucosa. Then the urethra is rotated over the graft back into its original position. Barbagli commented that the lateral opening of the urethral surface can avoid the pitfall of ventral and dorsal urethrotomy in patients with long strictures located in a full-sized bulbar urethra; that is, it enables one to avoid the erectile dysfunction and serious bleeding from thick spongiosum tissue that are caused by dissecting bulbar urethra from the corpora cavernosa [57].

Barbagli et al. described buccal mucosa lateral onlay bulbar urethroplasty in six patients. The first reference was at 42 months follow-up, and the same six patients were later described at 77 months follow-up [57, 72]. The success rate remained at 83% over this follow-up period. Kulkarni et al. reported their experience in 12 bulbar urethral strictures with short follow-up (mean 22 months); their procedure had a success rate of 92% [58].

16.4.4 Dorsal inlay

Asopa et al. described in 2001 a dorsal inlay technique using a dorsal free graft to treat urethral stricture by the ventral sagittal urethrotomy approach without urethral mobilization (Fig. 16.5) [56]. The urethra is slit open ventrally and the stricture is laid open. The full thickness of the dorsal urethra is then incised in the midline, providing an adequate elliptical raw area between the incised dorsal edges of the urethra. Grafts are placed over the raw area of the incised dorsal urethra (tunica albuginea of corporal body) and sutured to the edge of the incised dorsal urethra, making it possible to obtain an adequate urethral lumen width. The main advantage of the dorsal inlay is that the grafting space is created without circumferential mobilization of the urethra, thus preserving the circumflex and perforating arteries to the spongiosum. Additionally, proximal exposure of the stricture is easier than it is with the dorsal approach. However, compared with the dorsal onlay approach, the dorsal inlay graft contributes less to increasing the urethral caliber. The limited mobilization results in a relatively smaller potential graft width, which may limit the applicability of this approach to narrow strictures. Additionally, with the dorsal inlay graft there is more than one urethrotomy, potentially increasing the possibility of blood loss, urethral stricture, or fistula formation.

Pisapati reported the results of 58 patients who underwent bulbar urethroplasty with the dorsal inlay technique and the overall success rate at a mean follow-up of 42 months was 87% [73]. Aldaqadossi et al. conducted a prospective randomized study comparing the success rates of dorsal inlay and dorsal onlay BMG urethroplasties for 47 anterior urethral strictures and showed that they provide similar success rates (88% for dorsal onlay and 86.4% for dorsal inlay) [59]. Compared with dorsal onlay, dorsal inlay was shown to have a shorter operative time and less blood loss [59]. However, the main drawback of this technique is that the urethral plate needs to be more than 1 cm wide, and the graft that can be inlayed is typically narrower

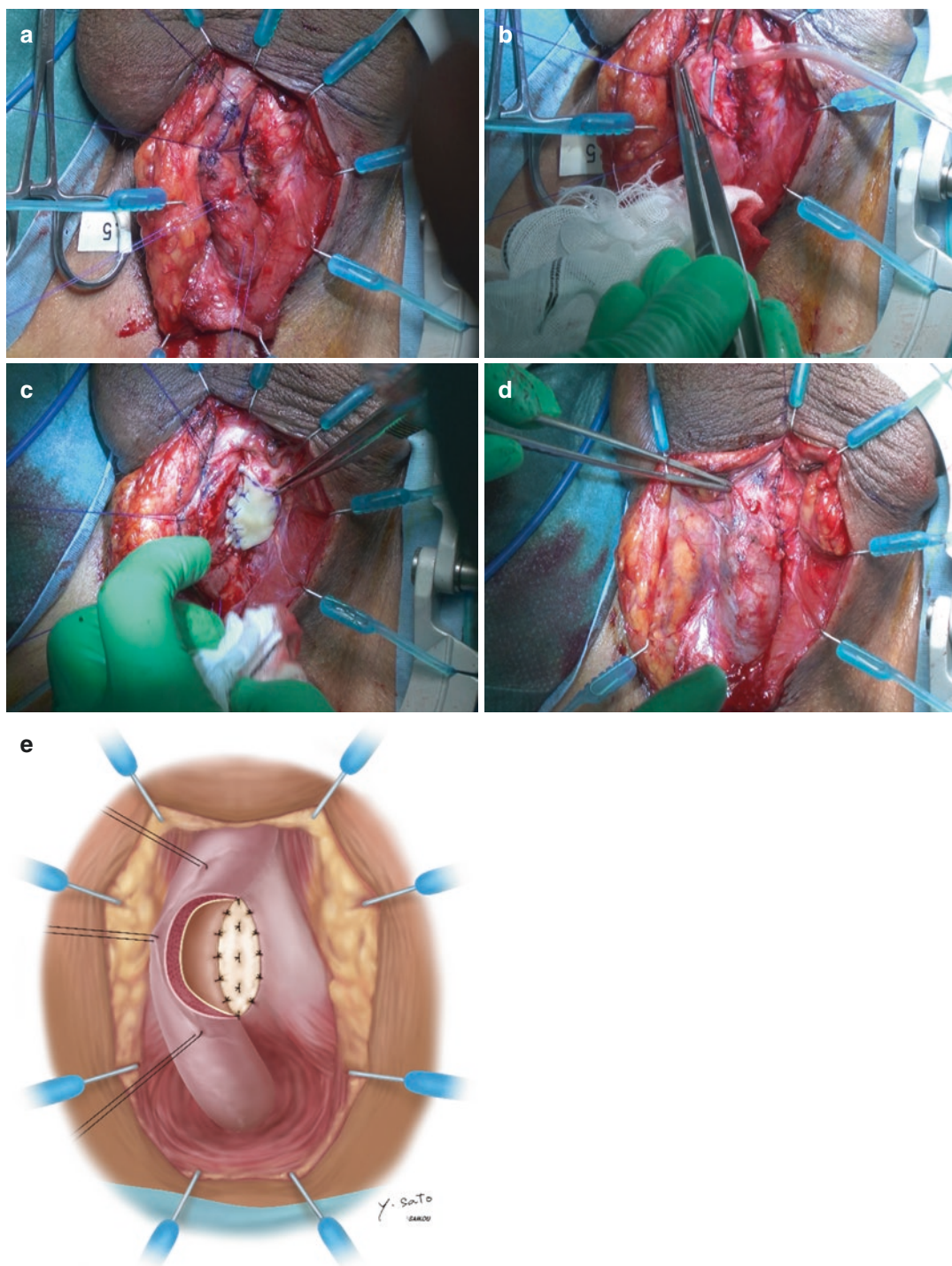


Fig. 16.4 Lateral onlay. (a) The urethra is mobilized from the albuginea only along the left side. (b) The dorso-lateral side of the urethra is incised longitudinally. (c) The graft is sutured to the underlying albuginea, and the right

margin of the graft is sutured to the left margin of the urethral plate (d) and on the other side. (e) Schematic image of lateral onlay

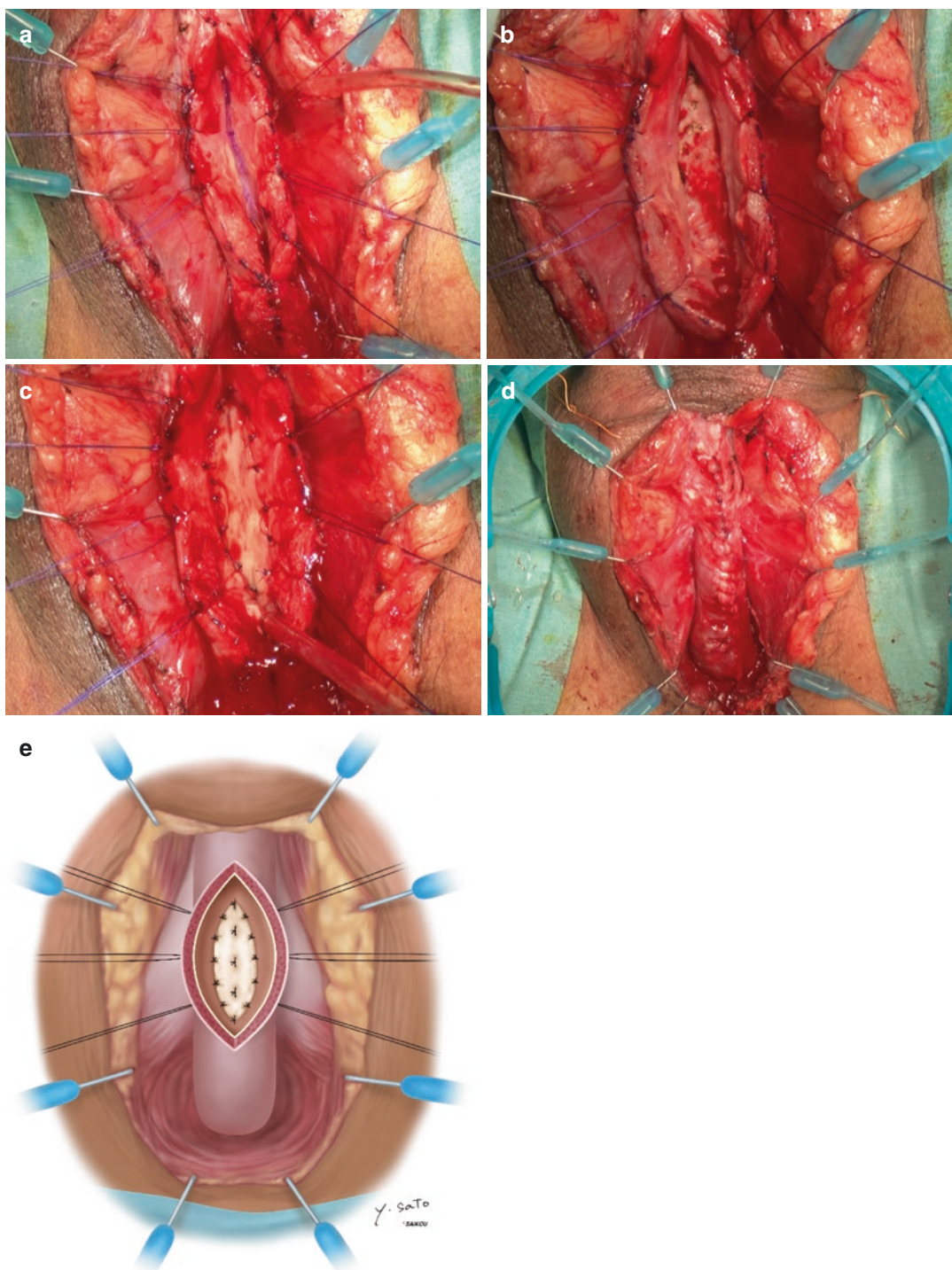


Fig. 16.5 Dorsal inlay. (a) The urethra is left adherent to the corpora cavernosa and is longitudinally opened ventrally extending to the distal and proximal healthy urethra. (b) The strictured urethral plate is longitudinally opened

dorsally. (c) The graft is sutured to the margins of the urethral plate and fixed to the corpora cavernosa. (d) The urethra is retubularized over a urethral catheter. (e) Schematic image of dorsal inlay

than the wide grafts that can be achieved with an onlay procedure [34].

16.4.5 Augmented Anastomotic Urethroplasty

Traumatic strictures and redo surgery with extensive scar tissue in the corpus spongiosum are two main indications for EPA in bulbar urethral strictures. As mentioned above, EPA provides for the most successful outcome in bulbar urethral reconstruction. However, there are times when, following stricture excision and urethral spatulation, too much tension would be present for a primary anastomosis. Excising strictured segments and making an anastomosis without tension is impossible, so using EPA for a long bulbar urethral stricture causes chordee. Nor can an adequate urethral lumen be achieved by an onlay augmentation on a single side. In 2001, Guralnick and Webster introduced the term “augmented anastomosis” to describe a combination of the two conventional approaches of excision with an onlay technique for bulbar strictures not amenable to either EPA or onlay augmentation [64]. In brief, the most obliterated segment of the stricture is excised, and stricturotomy is performed into the healthy urethra proximally and distally. Either the ventral or dorsal wall is then anastomosed and the remaining defect in the other side is repaired with a graft [64] (Fig. 16.6). With this technique, up to 2 or 3 cm of strictured urethra may be excised, followed by reapproximation of either the dorsal or ventral walls.

A series of 29 patients underwent an augmented anastomotic urethroplasty for bulbar stricture (mean length 1.5 cm) in which the ventral urethral strip was anastomosed and the dorsal defect augmented with a buccal mucosa graft. In that series the stricture-free rate at a mean follow-up of 28 months was 93% [64]. Hoy et al. reported the outcome of 163 patients who underwent the same procedure for longer bulbar strictures (mean 4.5 cm) and also showed excellent results: at the median follow-up of 31 months, 96.9% had no stricture recurrence [74]. This high success rate could be due to complete excision

of the narrowest stricture segment, which has the greatest risk of recurrence [74]. They also suggested that strictures longer than 5 cm are suitable to repair using this technique but can be associated with slightly greater recurrence rates. El-Kassaby et al. reported the outcome of augmented anastomotic urethroplasty using ventral onlay buccal mucosal patch grafts in 234 patients with long bulbar urethral strictures (mean 4.2 cm) and that with the mean follow-up of 36 months the overall success rate was 93.7% [75]. As in onlay augmentation, the different graft positions in augmented anastomotic urethroplasty have shown no difference in success rate.

16.4.6 Two-Sided Dorsal Plus Ventral Double Graft

Ideally, tight stricture segments should be removed, but transection procedures can impair sexual function as a consequence of the vascular damage and urethral shortening [14, 16, 19]. The use of augmented anastomotic urethroplasty is limited by stricture length, with the longest stricture treated with it in one prominent series being only 2 cm [64]. An EPA or augmented anastomotic urethroplasty may not be feasible in patients with longer obliterative segments. For these kinds of patients, a solution is a combined two-sided dorsal plus ventral double grafting. Two-sided dorsal plus ventral double grafting can be performed in two ways. One is a combination of ventral onlay with dorsal inlay technique described by Palminteri et al. [67], and the other is a combination of dorsal onlay with ventral inlay described by Gelman et al. [65]. In the former technique the stricture is opened ventrally without mobilizing the bulbar urethra and the exposed urethral plate is incised in the midline and augmented dorsally and ventrally using two oral grafts (Fig. 16.7a, b) [67]. Palminteri et al. reported a single-center experience with 166 patients who underwent a combination of dorsal inlay and ventral onlay technique for tight bulbar strictures: at a median follow-up of 47 months, 149 of the patients' repairs (89.8%) were successful [66]. In the latter technique the mobilized

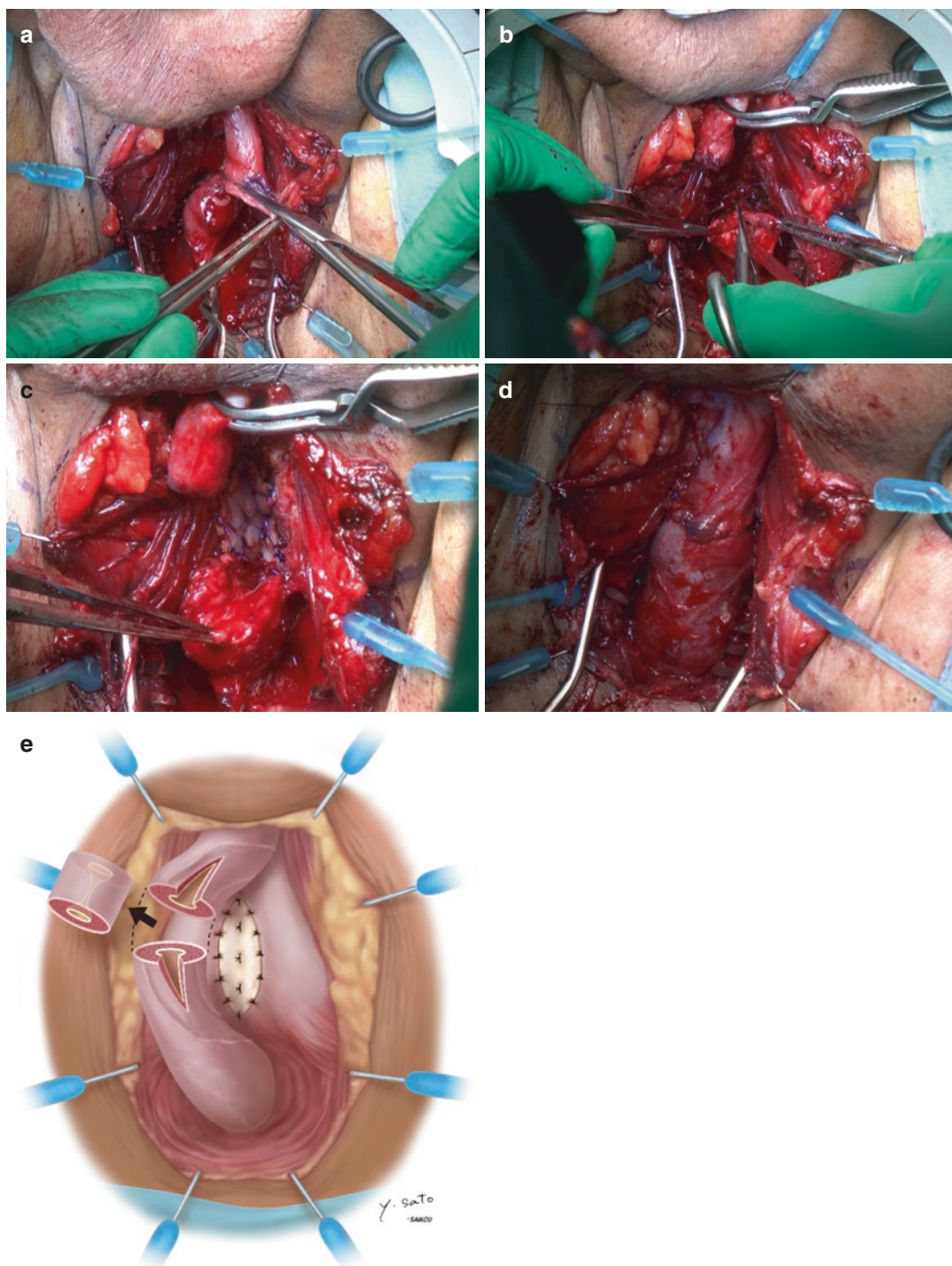


Fig. 16.6 Augmented anastomotic urethroplasty. (a) The bulbar urethra is circumferentially mobilized and a tight stricture is completely removed. (b) Both proximal and distal urethral walls are dorsally spatulated (c) and sutured

to the graft fixed over the corpora cavernosa. (d) The ventral side of the urethra is then closed. (e) Schematic image of augmented anastomotic urethroplasty

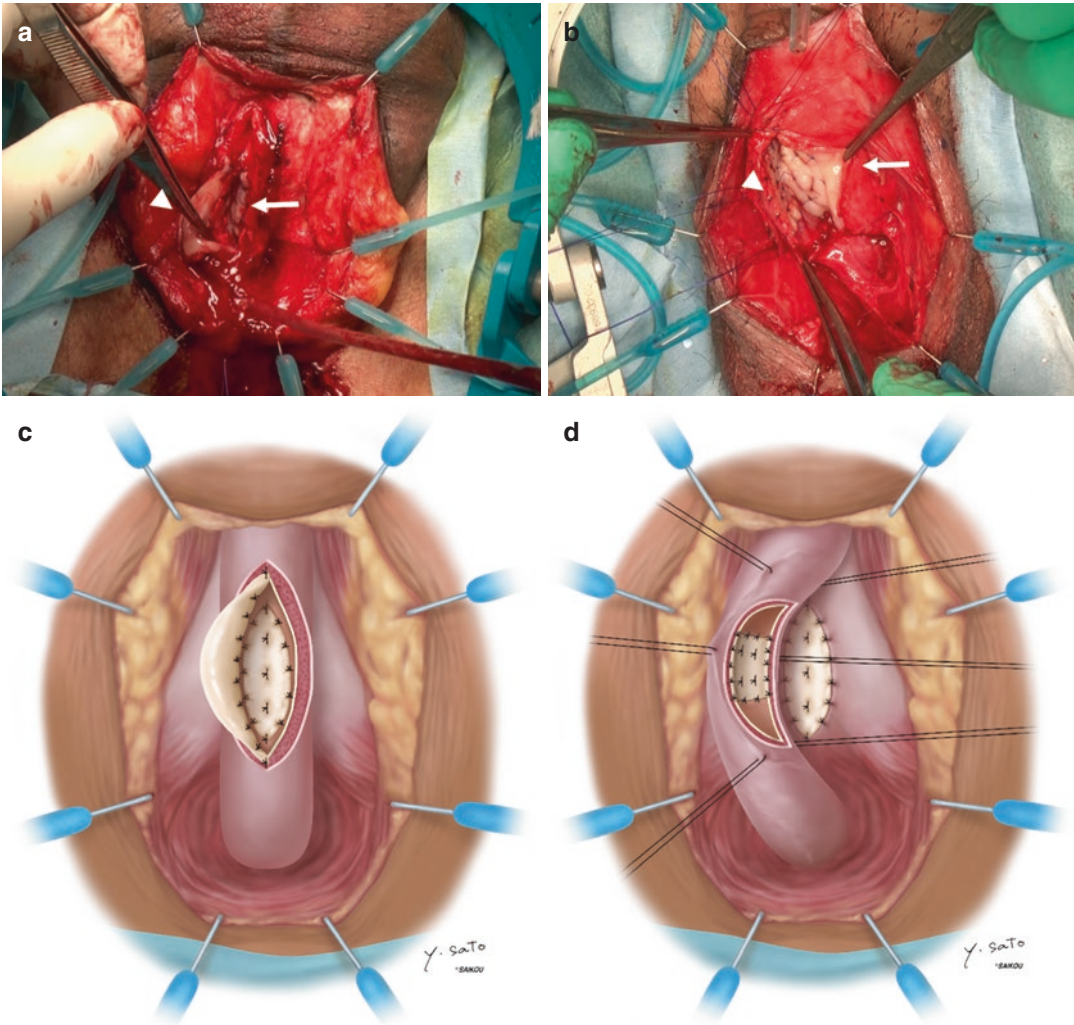


Fig. 16.7 Two-sided dorsal plus ventral double graft. (a) Combination of dorsal inlay (arrow) and ventral inlay (arrow head). Schematic image is shown in (c). (b)

Combination of dorsal inlay (arrow) and ventral inlay (arrow head). Schematic image is shown in (d)

corpus spongiosum is incised dorsally without transecting it, thereby preserving the continuity of the blood supply within the spongy tissue and also quilting buccal mucosa both dorsally on corpus cavernosa and ventrally on the spongiosum tissue (Fig. 16.7) [65]. Gelman et al. reported a series of 18 patients who underwent bulbar urethroplasty with two-sided double grafting combining dorsal onlay and ventral inlay techniques: with a mean follow-up of 50 months the success rate was 94% [65].

16.5 Postoperative Care

The incisions are dressed with hydrocolloid dressing followed by fluff gauze. A scrotal supporter is used to hold the dressing in place and to ensure gentle compression and immobilization that reduces edema without compromising blood supply. The perineum and cheek (donor site) are cooled with ice bags. Oral intake is started on the first postoperative day with liquid meals. To reduce donor site pain and promote wound

healing, we advise patients to gargle with saline containing sodium guaienate hydrate and lidocaine according to the level of pain. Whatever types are used, grafts rely on a healthy and well-vascularized recipient site for survival, and the initial blood supply via passive diffusion (imbibition) is gradually replaced by inosculation over the first 48 hours as host capillaries grow through the graft [76]. Therefore, it is important to keep a patient's mobility limited during the first 48 hours postoperative for secure fixation of the graft to the host bed. A 14–16 Fr 100% silicone catheter used as a stent and to divert the urine for two to three weeks is removed when a peri-catheter urethrogram shows no extravasation. Because most patients with urethral stricture have a significant post-void residual urine volume, perioperative antibiotics should be administered according to the results of urine culture and bacterial sensitivity checked prior to surgery until the patient's urethral catheter is removed. Even with antibiotics the failure rate is twice as high when the preoperative urine is infected [77].

There is no established follow-up strategy after urethroplasty. In our practice, patients are followed up at 3, 6, and 12 months and annually thereafter by uroflowmetry and questionnaires using validated patient reported outcome measures (PROMs) [78]. Flexible cystoscopy is done at the sixth postoperative month and whenever a recurrent stricture is suspected on uroflowmetry or from a PROM.

16.6 Conclusions

Substitution urethroplasty is the procedure of choice for a long stricture in the proximal bulbar urethra or a stricture of any length located anywhere from the distal bulbar urethra and for strictures in patients who worry about sexual dysfunction. BMG has become the best urethral substitute among various tissues. The key to success is to select an appropriate procedure according to the status and location of the stricture.

Key Summary Points

- Open surgical repair using free grafts or pedicled skin flaps, called substitution urethroplasty, is the gold standard procedure for bulbar urethral strictures not amenable to excision and primary anastomosis.
- Buccal mucosa harvested from inner cheek is an ideal urethral substitute and is the tissue most often used for substitution urethroplasty because of its compatibility with urethral tissue and the ease of harvesting and handling it.
- Most bulbar urethral strictures can be repaired by one-stage urethroplasty, and buccal mucosa graft onlay augmentation is the most preferred procedure.
- Onlay augmentation on the ventral side (ventral onlay) or dorsal side (dorsal onlay) has been widely used, and other options are dorsal inlay with ventral sagittal urethrotomy or lateral onlay with one-sided urethral dissection. Regarding the association of the graft position and the success rate, there is no significant difference in surgical outcome among the different graft positions.
- In bulbar urethral strictures with obliterative or nearly obliterative segments, either a two-sided dorsal plus ventral onlay augmentation or a combination of excision and primary anastomosis and onlay augmentation (augmented anastomotic urethroplasty) is the procedure of choice.

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Surgical Reconstruction of Panurethral Stricture Disease

17

Pankaj M. Joshi, Faisal Alhajeri,
and Sanjay B. Kulkarni

17.1 Introduction

Panurethral strictures involve the urethra from the meatus to the bulbomembranous junction. Lichen sclerosus and iatrogenic causes are two of the most common causes of panurethral strictures. Iatrogenic causes are on the rise, especially because patients are often subjected to dilatation and intermittent self-catheterization. The best option for management of a panurethral stricture is urethroplasty. We have published extensively on the management of panurethral stricture and the change from dilatations to flaps to grafts. The manuscripts are available in the Hinmans Atlas of Urology and UCNA [1–3]. In this chapter, we wish to highlight the decision-making process, surgical craft tips and the management of complex panurethral strictures.

17.2 Materials and Methods

At our tertiary referral center for the management of urethral strictures in Pune, we have received patients from all over India and the world, including patients with panurethral strictures. We have performed more than 4350 surgeries to date. A detailed history of the patient is taken, including any previous surgery. The clinical examination

involves looking for lichen sclerosus. Occasionally, patients will have urinary retention and they are then referred with a suprapubic tube. Ultrasound is performed to look for renal health and rule out hydronephrosis. Uroflow forms an integral part of the workup as a baseline test. Usually patients come with a urethrogram. In our unit, we perform the urethrogram ourselves in the operating room (OR) under C-Arm on the day of urethroplasty. Patients are given povidone iodine gargles and Povidine iodine or Chlorhexidine for local application to prepare for mucosal mucosa grafting. Third generation cephalosporin IV antibiotic is started the evening prior to surgery. The surgical technique will depend on the type of panurethral stricture.

17.3 Surgery Techniques

17.3.1 Panurethral Strictures: Single Stage Versus Two Stage

The results of a randomized study by Dubey et al. [4] suggested the use of a single stage Buccal graft urethroplasty versus a staged approach. A multicenter study by Warner et al. [5] highlighted the use of a single stage approach over a staged approach and flaps in many high-volume centers across the globe. We tend to have a single stage approach as much as possible which has now been proven by the above two studies. This is important in lichen sclerosus which is a genital

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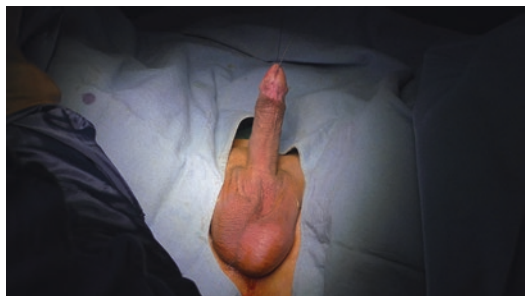


Fig. 17.1 Lichen sclerosus causing Panurethral stricture



Fig. 17.2 Injecting methylene blue in urethra

skin disease and where two staged urethroplasty is not recommended due to the risk of recurrence. (Fig. 17.1)

Our approach is to perform a small caliber endoscopy using a 4.5 Fr ureteroscope. Occasionally we have seen urethral stones and bladder stones which had to be addressed intraoperatively and would otherwise have been missed.

If the urethra accepts a 4.5 Fr ureteroscope or a 3 Fr guide wire, it can be managed with a single stage approach.

17.3.1.1 Positioning and Initial Steps

The patient is nasally intubated and two teams work simultaneously at the donor and the recipient site, with separate sets of instruments. The oral mucosa is harvested from both cheeks as described by Barbagli et al.(ref) The patient is placed in a simple lithotomy position, with heels carefully placed in Yellofin® stirrups (Allen Medical Systems, Acton, MA; USA) with no pressure on the calves, to avoid peroneal nerve injury. The suprapubic, scrotal and perineal skin is shaved, disinfected using chlorhexidine, and draped. Methylene blue is injected into the urethra.

17.3.1.2 Incision

Methylene blue stains the strictured urethra. It helps in identifying the lumen (Fig. 17.2). A midline perineal incision is made and the bulbospongiosus muscle is exposed. In the lower half, the muscle wraps around the bulbar urethra. In the upper half, a sleeve of muscle extends to the corpora (Fig. 17.2). This is the bulbocavernosus part (Figs. 17.3 and 17.4). Only this part of the

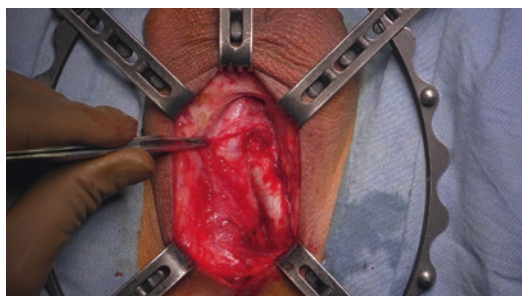


Fig. 17.3 Incising bulbocavernosus muscle

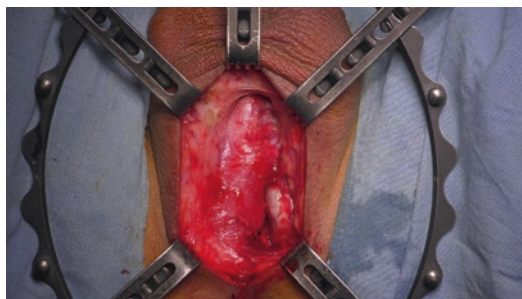


Fig. 17.4 One side dissection of bulbospongiosus muscle

muscle is incised to gain access to the dorsal wall of the urethra. This is therefore a muscle preserving urethroplasty technique.

17.3.1.3 Penile Invagination

The trick to invaginate the penis is to incise on the fascia above the urethra. Typically, a right-handed surgeon would use his left hand to push the penis down in the perineum and the dissection is performed on the left side of urethra (Fig. 17.5). By using the push technique and dissection, the penis can be invaginated.



Fig. 17.5 Penile Invagination

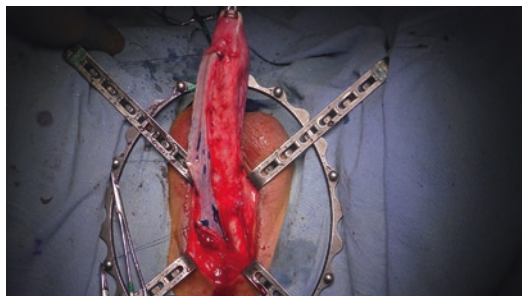


Fig. 17.7 Dorsal urethrotomy



Fig. 17.6 One sided dissection of anterior urethra



Fig. 17.8 Dorsal Meatotomy

The step is simple and would not take more than 5 minutes even in novice hands provided the plane is correct. We were able to invaginate the penis even in redo cases where it could be challenging.

17.3.1.4 Urethral Dissection

The urethra is dissected from the underlying corpora similar to the dorsal onlay technique. Care needs to be taken that one does not enter the intercrural plane. The urethra is rotated on the long axis without mobilising circumferentially. The neurovascular supply from the right side is kept intact (Fig. 17.6).

17.3.1.5 Urethral Incision

A dorsal incision is made in the urethra across the full length (Fig. 17.7). Proximal one needs to be beyond the stricture and should see good pink supple urethral lumen. We use a broad Debakey forceps to retract the urethra intraluminally. The forceps should lie horizontal to the ground. This means the dissection has been completed. Proximal the urethra turns in to the perineum to

become almost horizontal, therefore the forceps should lie horizontal. Any angle means that our dissection proximal may not be complete and this can be a cause of proximal failure. Distal dissection is done up to the fossa navicularis. The penis is brought back to the pubic region and a small Debakey forceps is inserted in the meatus. A wide dorsal meatotomy is performed externally (Fig. 17.8). This meatotomy should meet the dorsal incision in the urethral plate.

17.3.1.6 Buccal Graft

We use a team approach. Another team simultaneously harvests the buccal grafts. In most of the cases we require two long buccal grafts with a width of 1.5 cm. Occasionally a third graft may be needed which can then be harvested from the undersurface of the tongue. We tend to keep the graft area open. We discourage the use of lip grafts. They have a high incidence of cosmetic disability compared to the cheek grafts. The literature may suggest otherwise, but the use of lip grafts is declining in the majority of high volume centres.

17.3.1.7 Graft Placement

The first buccal graft is sutured to the dorsal apex of the meatus (Fig. 17.9) and is then pushed into the penile urethra and spread and fixed to the corpora cavernosa over the midline (Fig. 17.10). Another buccal graft is applied to the corpora cavernosa opposite the bulbar urethra. Continuous upward traction is applied to the inverted penis while applying the penile graft to prevent chordee. The grafts are 1.5 cm in width; they are spread and fixed with quilting sutures (Fig. 17.11). The

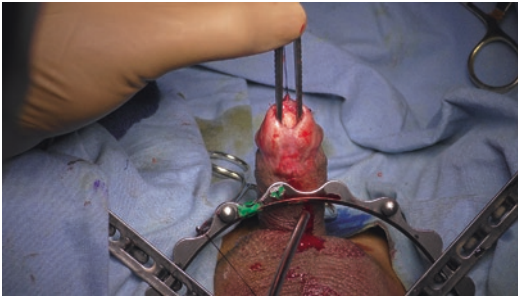


Fig. 17.9 Dorsal graft at meatus

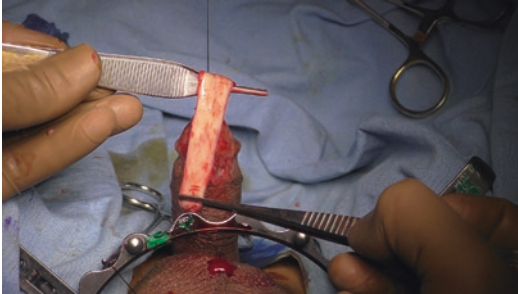


Fig. 17.10 Graft pushed in urethra through the meatus

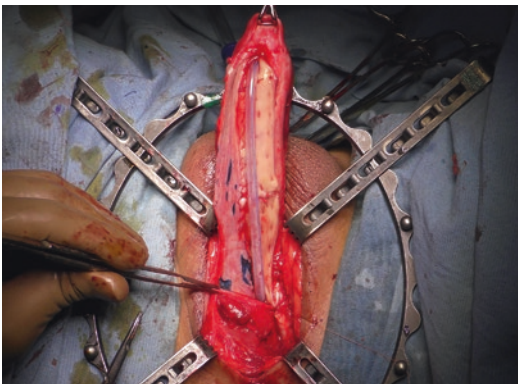


Fig. 17.11 Quilted grafts and urethral closure

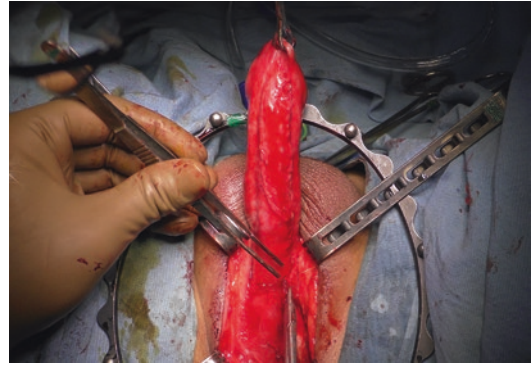


Fig. 17.12 Closure of bulbocavernosus muscle

buccal graft margin is sutured to the (patient's) right side of the urethral plate, and a 14 Fr silicone catheter inserted. The full length of the urethra is rotated back to its original position over the graft. Continuous 4-0 polyglactin suture is used to stabilize the urethral margins onto the corpora cavernosa on the left. By the end of the procedure, the graft is completely covered by urethra and muscle (Fig. 17.12). Colles' fascia, perineal fat and skin are closed with interrupted absorbable sutures. The catheter is maintained for 4 weeks.

17.3.1.8 Postoperative Care and Follow-Up Criteria

The patient is started on per oral diet 3 hours after anaesthesia. The initial diet essentially includes liquids and ice-cream. We ask the patients to avoid hot, spicy and hard food for about 4 weeks. The patient ambulates on postoperative day one and is usually discharged in the evening on day one. All patients receive postoperative IV broad-spectrum antibiotics until the morning after surgery and then oral antibiotics (Quinolones) until the catheter is removed. We do not perform pericatheter urethrograph for all cases. It is done for redo urethroplasty and is performed 4 weeks postoperatively, and if no leak, the catheter is removed. The patient performs Uroflowmetry at 3, 6 and 9 months post-operatively and then annually, or sooner if clinically indicated. If the patient experiences a decreased force of stream and Uroflowmetry less than 12 ml/second, further investigation is undertaken, including Urethrography, urethral ultrasound, and urethrocystoscopy.

Due to the fact that patients are referred to us from across the country and globe, we have been using net-based applications to communicate with our patients. Patients are requested to follow up with the referring urologist and have uroflowmetry done and the information is then shared with us via email or WhatsApp[®].

Patients are requested to follow up personally in their clinic in case of poor flow and where some intervention may be necessary. Internet-based applications have significantly reduced the travelling time of patients.

17.3.1.9 Our Results

The study is an observational, descriptive, retrospective and prospective analysis in 401 consecutive male patients. Inclusion criteria were fit males ranging from 20 to 76 years age with pan-urethral strictures. The average stricture length varied from 10 to 19 cm. The primary outcome measure was success of surgery, and the secondary end point the treatment of failures. Clinical outcome was considered a failure when any instrumentation was necessary, including dilation.

Median patient age was 44.6 years (range 20–76). The overall median follow-up was 71 months (range 6.4–202). The mean stricture length was 14 cm, with a range of 10–19 cm. Of 401 patients, 358 had no previous urethral surgery, and 43 had undergone previous failed urethroplasty. Out of the 401 patients, 336(83.79%) were successful and 65 (16.21%) failures. Failure was seen most commonly in patients with obliterative strictures on SPC.

No patient had a full-length recurrence. When a stricture recurred, it was at the proximal end of the graft, the junction of two grafts, or the meatus (Fig. 17.13). Meatal strictures are treated with Meatoplasty. The proximal bulbar stricture can manifest as a ring and can be incised once. In case of failure, ventral onlay buccal graft urethroplasty can be performed. The stricture at the junction of two grafts can be treated by dilatation, DVIU or dorsal inlay buccal graft Asopa technique.

17.3.1.10 Chordee

Some urologists have reported chordee after pan-urethroplasty. The trick to avoid chordee is to



Fig. 17.13 Sites of recurrence

harvest long optimal grafts. While quilting the graft it is important to keep the penis stretched and not the graft. Any excessive stretching of the graft may result in chordee. It is easier to harvest a third graft rather than stretch a graft and try to bridge the length of the stricture.

17.3.2 Redo Panurethral Strictures

We have been getting referrals for redo pan-urethral strictures. It is common in our tertiary referral centre to perform redo single stage urethroplasty for panurethral strictures. The approach to such cases depends on previous surgeries. If previously a staged Johanson's urethroplasty was performed, it is challenging to invaginate the penis. This can be judged by feeling the skin over the underlying urethra. In such complex patients, a ventral urethrotomy is performed and the urethra opened across the full length from the meatus to the most proximal bulbar urethra. A midline incision is made in the urethral plate. OMG are harvested and inserted as dorsal inlay across the full length of the urethra. The augmented urethra is then tubularised and a second layer closure is performed with dartos tissue.

Another approach is the minimally invasive Kulkarni approach of penile invagination through

perineal incision. Assuming that previous urethroplasty was performed with a dorsal approach, it is challenging to mobilise the urethra dorsally again. Hence the urethra is incised ventrally across the full length of the urethra and dorsal inlay OMG urethroplasty is performed.

Given a choice we would perform a penile invagination urethroplasty to avoid any incision on the penis and make it a minimally invasive cosmetic urethroplasty.

17.3.3 Panurethral Stricture with Short Obliterative Segment

As our experience increases, we receive referrals for panurethral stricture with complete obliteration in short segments, most commonly in the bulbar urethra. These patients are on suprapubic catheters and after having done an urethrogram an obliterative segment was revealed. Our approach has been to perform a single stage, one sided dissection, dorsal onlay buccal graft augmentation along with a double face buccal graft augmentation at the obliterated segment (Fig. 17.14). We have performed this technique in nine patients. Eight patients had a narrow segment in the bulbar urethra and one patient had a narrow segment in the penoscrotal junction. Eight of the nine patients have had successful, dilatation free voiding over the last 34 months.



Fig. 17.14 Double Face for Obliterative stricture

17.3.4 Panurethral Stricture with Long Obliterative Segment

Occasionally, there is a patient with a long segment panurethral stricture with complete obliteration. These patients are usually very motivated to pass urine from the tip of the penis versus a diversion. Such long segment obliterations merit a substitution urethroplasty. It often needs a combination of grafts and flaps. We have performed this reconstruction using two buccal grafts applied dorsally and creating a ventral wall by using a pedicled “Q” flap penile skin urethroplasty (Fig. 17.15). Other options could

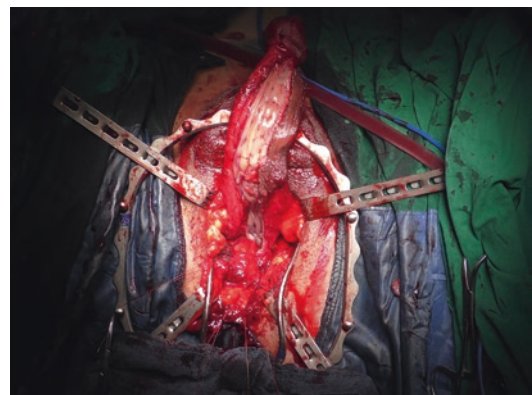


Fig. 17.15 Single stage dorsal BMG with ventral “Q” penile skin flap

be a tube pedicled penile skin urethroplasty or an enterourethroplasty.

17.3.4.1 Development of the Kulkarni Technique

Dr. Kulkarni performed urethrectomy for bladder cancer using penile invagination during his training in the UK. Panurethral strictures were mainly treated by two stage procedures until the 1990's. Dorsal onlay buccal graft urethroplasty was popularized by Barbagli in 1996. Dr Kulkarni performed dorsal onlay buccal graft urethroplasty for panurethral strictures in India. The penile urethra was approached through a circumcision incision and the bulbar urethra through a perineal incision. The penoscrotal junction is a watershed area producing technical difficulty. Dr Kulkarni applied the penile invagination technique and performed a dorsal onlay buccal graft urethroplasty for panurethral incision through the perineum. By invagination, the full anterior urethra was now visualized as a single unit. The concept of meatotomy with graft insertion from the meatus till the proximal bulb was now possible through a single incision in the perineum. Initially the urethra was mobilized circumferentially. Barbagli and Kulkarni published the techniques of muscle sparing bulbar urethroplasty [6]. The one side dissection technique was then amalgamated with the Kulkarni technique, thereby further refining it. Today the technique consists of a single stage, penile invagination, one side dissection and dorsal onlay buccal graft urethroplasty. This approach is widely followed across reconstructive urology units and opens up the possibility of treating penile urethral strictures without an incision on the penis. Currently, many centers perform penile urethroplasty with penile invagination.

17.4 Discussion

The management of panurethral strictures traditionally include dilatation and intermittent catheterization. Johanson's urethroplasty gave the option of a two stage urethroplasty. Technically panurethral strictures extend till the bulbomembranous junction and it is challenging for an

urologist to do a staged urethroplasty up to that level. The commonest cause of panurethral strictures is lichen sclerosus. This is a genital skin disease and two stage urethroplasty is not recommended. It would have the risk of involving the genital skin as part of the urethra and lead to recurrence.

Dubey et al. reported on their experience comparing the one-stage Kulkarni technique and two-stage repairs for panurethral strictures secondary to lichen sclerosus¹⁶. They concluded that one-stage procedures had better success, and while staged procedures could be successful, they were fraught with technical difficulties and multiple revisions [4].

A very recent transcontinental multi-institutional study done by Warner et al. reported on the complication rates of different surgical techniques to repair long-segment and panurethral strictures [5]. The complication rate was higher in the fasciocutaneous cohort compared with those without a flap (32% vs 14%, respectively; $p = 0.02$). In this review, a two-stage Johanson's urethroplasty was not as successful as the buccal mucosal graft procedure (BMG) (64% vs 82.5%, respectively). It was found that two-stage Johanson's urethroplasty performed with skin had a higher failure rate than those performed with a BMG (66.7% recurrence rate vs 28.3%, respectively). Flaps have higher complication rates as compared to one stage urethroplasty. Fasciocutaneous flaps are also technically demanding and require plastic surgery training.

Spencer et al. published data on PROM after the Kulkarni urethroplasty [7]. They concluded that the Kulkarni urethroplasty has a high patient satisfaction rate. It is a safe, successful and reproducible technique. It has minimal impact on erectile function as compared to other techniques and it improves the ejaculatory function after urethroplasty.

17.5 Conclusion

One-stage repairs with BMG as reported by Kulkarni et al. offer an excellent option for patients with long-segment and panurethral

stricture disease. In cases with obliterative or absent urethral plate, a 2-stage Johanson urethroplasty with BMG offers a viable alternative. In cases of LS, 1-stage BMG has better outcomes than a 2-stage repair. If BMGs are not available, FC flaps may offer equivalent outcomes; however, these are associated with higher complication rates. Skin grafts should be avoided, unless no alternatives exist. Finally, the valuable role of PU cannot be understated in the setting of multiple failed urethroplasties.

Key Summary Points

- One-stage repairs with BMG offers an excellent option for patients with long segment and panurethral stricture disease.
- In case of LS, single stage buccal graft urethroplasty should be the procedure of choice
- In cases with obliterative or absent urethral plate, panurethroplasty with double face at the obliterative site can be performed.
- The Kulkarni technique for panurethral urethroplasty is minimally invasive with excellent postoperative outcomes, improved cosmesis, and excellent functional outcomes.

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Surgical Reconstruction of Failed Anterior Urethroplasty

18

Adam Miller, Allen F. Morey, and Boyd R. Viers

18.1 Summary

Urethroplasty has proven to be a cost-effective first-line treatment option for urethral stricture disease. In contemporary series, long-term success rates exceed 90% for anastomotic techniques and 85% for substitution urethroplasty. Urethroplasty failure can often be successfully salvaged with a subsequent reconstructive procedure, the success rates of which approach 80% employing various novel reconstructive techniques.

Anastomotic repairs typically fail due to lack of complete scar excision (usually from the proximal urethra) and/or inadequate distal urethral mobilization leading to tension on the anastomosis. Substitution urethroplasty may fail secondary to graft/flap contracture at the proximal or distal extent of the urethrotomy, often resulting from poor vascular supply of the graft bed or flap ischemia. Treatment of failed penile urethral strictures are best managed with a flap procedure involving penile shaft skin, buccal mucosa, or a combination thereof. It is critical to remove any

residual scar, sacculation/redundancy, or hair-bearing tissue from prior reconstructive procedures that may impede tissue healing. Extended meatotomy is an effective technique for addressing refractory distal stenosis.

In the bulbar urethra, re-excision and primary anastomosis is reserved for mid to proximal bulbar strictures, with success reliant upon adequate mobilization and utilization of the elastic properties of the distal urethra to bridge the gap. Onlay grafting can be considered for lengthy non-obliterative mid- or distal bulbar strictures. A diverting “loop” perineal urethrostomy is an excellent option in select cases of recalcitrant lengthy anterior urethral strictures where additional adjunctive maneuvers may be at risk of failure. For recurrent stenoses that are focal with minimal spongiofibrosis, a single urethral dilation or DVIU can be considered.

18.2 Introduction

Primary urethroplasty is considered the gold standard treatment option for the management of anterior urethral stricture disease due to its high success rate and durability. In contemporary series, long-term success rates exceed 90% for anastomotic techniques and 85% for augmented urethroplasty [1–5]. For the small percentage of patients who fail even with experienced surgeons, salvage urethroplasty is an effective treatment

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option with success rates comparable to primary urethroplasty [2, 6–12].

The type of urethroplasty to be performed is dictated by the length, location, and density of the recurrent stricture [6] while taking into consideration the viability of tissue adjacent to the reconstructive field. Ultimately, many failures can be salvaged with a carefully planned revision urethroplasty. Herein, we will discuss the most common etiologies of anterior urethroplasty failure and review our preferred subsequent management of these complex patients.

18.3 Causes of Failure

18.3.1 Patient Comorbidities

Treatment failure has been associated with obesity, diabetes, hypertension, malnutrition, spinal cord injuries, advanced age, and tobacco abuse [11, 13]. Hypogonadism may also play a role in urethroplasty failure as this has been associated with urethral atrophy and a reduction in periurethral vascularity among men with urethral stricture disease [14–16]. Coexisting conditions in aging men are more likely to influence urethroplasty success than age alone, including prior radiation, prostate cancer treatment, peripheral vascular disease, and hypogonadism with urethral atrophy. In general, despite these challenges, urethral reconstruction in aging male patients appears to be safe and effective [17, 18]. Age alone should not be a contraindication to urethral reconstruction, but only one factor to be considered in the context of other competing conditions which may influence urethroplasty technique and expected outcomes [18].

18.3.2 Endoscopic Intervention

In many cases, prior to referral for formal reconstruction, patients with urethral strictures undergo a period during which repetitive temporizing endoscopic treatments are performed for recurrent obstructive symptoms. The repetitive trauma of multiple endoscopic urethral

manipulations appears to be associated with lengthier strictures requiring more complex repairs [19]. This is a cost in-effective practice [20] which may ultimately place the patient at greater risk of subsequent reconstructive failure [11, 19, 21, 22].

18.3.3 Stricture Etiology

The most common contemporary urethral stricture etiologies include idiopathic (37%), iatrogenic (28%), and acute trauma (15%) [23]. Men with idiopathic urethral strictures often have clinical features suggestive of unrecognized or repetitive perineal trauma and these men often experience a delay in definitive management (median 5.2 years) with multiple endoscopic treatments (median of 2) prior to definitive repair [23]. Interestingly, these men have a high rate of urethroplasty success because most are short bulbar strictures amendable to anastomotic urethroplasty [23]. Men with prior open or repetitive endoscopic urethral manipulation [21], strictures of infectious etiology [13], prior hypospadias repair [4], lichen sclerosis (BXO) [24] and/or radiation [10] are more prone to urethroplasty failure.

18.3.4 Urethroplasty Technique

Failure of anastomotic urethroplasty is most often due to inadequate excision of fibrosis at the proximal aspect of the stricture and/or inadequate distal bulbar mobilization resulting in anastomotic tension [6]. In general, this procedure is suited for mid to proximal bulbar strictures 1–3 cm long where a well vascularized tension-free, two-layer anastomosis can be achieved. Anastomotic urethroplasty for penile and lengthy distal bulbar urethral strictures may predispose to anastomotic tension, increasing the risk of treatment failure. These recurrent stenoses can often be dense, but the select use of a single direct vision internal urethrotomy in the absence of significant spongiofibrosis has been described as a successful treatment option [25, 26].

Substitution urethroplasty failure can occur at the proximal or distal aspect of the reconstruction bed due to graft or flap contracture or inadequate urethrotomy extension into viable, well vascularized tissue. These recurrences often occur early and are usually thin and membranous in nature and may respond well to simple endoscopic dilation. Complex, lengthy, and dense stricture recurrences following substitution urethroplasty may occur as a result of flap ischemia or poor graft “take” – both a function of adequate vascular supply. Undue tension on the flap pedicle or coexistent microvascular disease may compromise a fasciocutaneous flap repair. Similarly, inadequate excision of tissue bed fibrosis results in poor vascular and structural support of any grafted tissue.

18.4 Evaluation

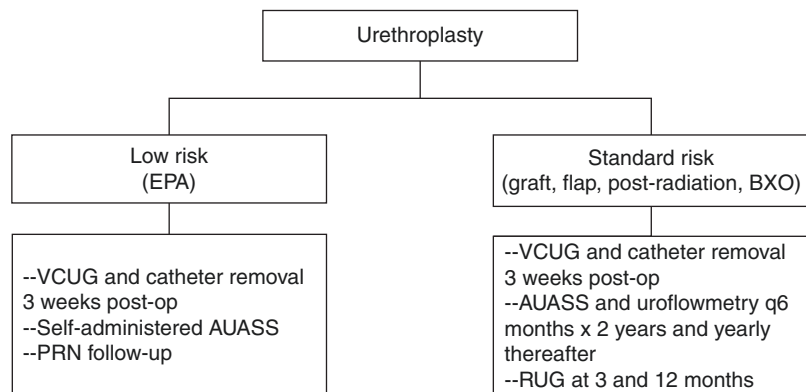
Urethroplasty failures often present in a symptomatic fashion within weeks of catheter removal following the original procedure. Patients usually note progressive worsening of obstructive urinary symptoms and/or recurrent urinary tract infection (including epididymitis or prostatitis). The American Urological Association Symptoms Score (AUASS) Index combined with urinary flow rate testing is a useful initial diagnostic tool for symptomatic men with a history of prior urethral reconstructive surgery [27–30]. Retrograde urethrography, voiding cystourethrography and/or cystourethroscopy are useful to further characterize the nature of treatment failure [31].

Currently, there is no standardized surveillance protocol after open urethral reconstruction; however, most surgeons use a combination of questionnaires, noninvasive testing such as uroflowmetry, and invasive procedures such as retrograde urethrography, voiding cystourethrogram, and/or cystoscopy [32]. Noninvasive testing such as uroflowmetry combined with standardized questionnaires [AUASS, urethral stricture surgery specific patient reported outcome measure (USS-PROM), International Prostate Symptom Score (IPSS)/Visual Prostate Symptom Score (VPSS)] can play a critical role in screening for stricture recurrence in asymptomatic patients [33].

One barrier to developing a standardized protocol is lack of consensus on a definition of urethroplasty failure. We define failure as urethral narrowing found to be endoscopically impassable with a 17 French flexible cystoscope. Patients can be safely observed if a 17 Fr cystoscope can pass without difficulty. In the event that cystoscopy is not available, gentle urethral calibration with a 14Fr straight catheter is an effective first measure to identify those who may have a clinically significant stricture recurrence.

We recommend a risk-stratified, symptom based surveillance protocol (Fig. 18.1) [34]. Adopting a risk-stratified approach can significantly reduce health care costs while minimizing unnecessary follow-up visits, invasive testing, and radiation exposure [34]. The yield of invasive testing is relatively low for most patients undergoing urethroplasty given the high success rates. Low risk patients (EPA) may be followed as

Fig. 18.1 Risk stratified follow-up protocol following anterior urethroplasty. PRN, as necessary. (Adapted from Belsante et al. [34])



needed based on symptomology, whereas for standard risk we advocate for non-invasive testing with uroflowmetry and standardized questionnaires at 6 months for 2 years and then annually thereafter. Invasive testing should be reserved for those at increased risk of failure (BXO, radiation, prior hypospadias repair, lengthy flaps or grafts) and in those who develop symptoms after urethral reconstruction.

During post-urethroplasty surveillance, it is common to identify irregularities from the prior repair such as sacculation, redundancy, or tortuosity; these should be observed as long as they are asymptomatic. However, for those patients with symptomatic stricture recurrence, accurate imaging is essential (Fig. 18.2). Flexible urethroscopy should also be performed to further assess the stricture (Fig. 18.3). Precisely characterizing the location, length, density, and diameter of the stric-



Fig. 18.2 Voiding cystourethroscopy combined with retrograde urethrography (up-and-down-o-gram) demonstrating complex synchronous bulbar urethral strictures in a patient with previous dorsal inlay and ventral onlay buccal mucosa urethroplasty

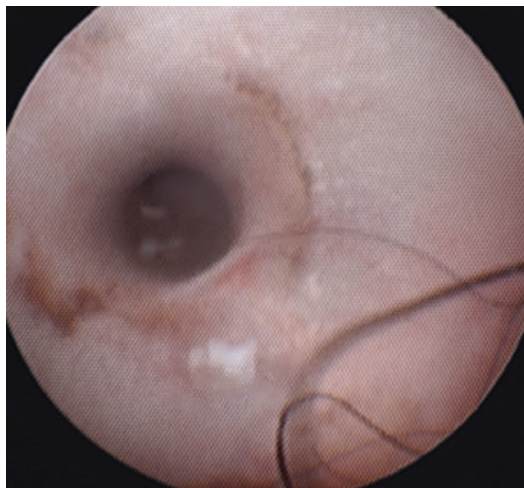


Fig. 18.3 Urethroscopic image of prior skin flap repair using hair-bearing skin with proximal stricture

ture is critical for surgical planning and ultimately salvage urethroplasty success. If the patient has undergone recent endoscopic instrumentation or is performing urethral self-dilation to maintain patency, suprapubic tube placement and urethral rest for a period of 6–8 weeks is warranted. While rare, in the event of rapid stricture recurrence, or suspicious findings on imaging or urethroscopy, urethral stricture biopsy must be considered to rule out malignancy.

18.5 Patient Counseling

18.5.1 Salvage Urethroplasty Outcomes

Considerations and outcomes of revision urethroplasty differ from primary urethroplasty. To ensure realistic expectations, patient-surgeon discussion must highlight expected outcomes and operative morbidity. While outcomes for primary urethroplasty exceed 90% depending on stricture location and repair type [1–4], success rates for revision urethroplasty are less (Table 18.1) [6, 8, 12, 35, 36]. Salvage reconstructive success is influenced by extent of operative bed fibrosis, degree of vascularity, and availability of healthy uncompromised surrounding tissue.

Table 18.1 Summary of select studies reporting salvage urethroplasty outcomes

Author(s)	Year	No. patients	Follow-up (mos.)	Location	Type of reconstruction	Success rate
Pagliara et al. [36]	2017	133	17	Bulbar, penile	EPA, substitution urethroplasty, perineal urethrostomy	Tertiary: 90% EPA, 50% substitution, 100% urethrostomy
Rosenbaum et al. [37]	2016	50	25.6	Bulbar, penile	Buccal mucosa graft	Stricture free survival 91%, 86%, and 81% at 12, 24, and 36 months
Siegel et al. [12]	2015	37	41.5	Bulbar	EPA	95% after prior EPA, 94% after non-EPA prior urethroplasty
Blaschko et al. [10]	2012	130	55	Prostatomembranous, bulbar, penile	EPA, flap, graft, combined	78%
McLaughlin et al. [38]	2006	57	29.6	Bulbar	Buccal mucosa graft	94%
Joseph et al. [8]	2002	58	–	Bulbar, penile	EPA, flap, graft, 2 stage substitution	EPA 96%, graft and flap 21% revision rate for single stage, 23% for 2 stage
Morey et al. [6]	1997	31	>12	Bulbar, penile	EPA, flap and graft substitution	90% overall success (100% for EPA, 100% for patch graft, 79% for penile fasciocutaneous flap)
Barbagli et al. [35]	1996	20	57	Bulbar, penile	EPA, patch graft, 2 stage procedure	Penile: 3/8 “excellent” 5/8 “satisfactory” Bulbar: 9/12 “excellent” 3/12 “satisfactory”

EPA excision and primary anastomosis

In our experience of 573 consecutive urethroplasty cases including 87 (15%) secondary, and 46 (8%) tertiary (>2) procedures, we found urethroplasty failure rates were significantly higher for tertiary cases (37%) vs 20% and 13% for secondary and primary procedures [36]. Success rates of perineal urethrostomy (100%) and excision primary anastomosis (90%) were far greater than for substitution urethroplasty (50%) [36]. Importantly, while salvage urethroplasty is associated with an increased risk of treatment failure relative to primary urethral reconstruction, with the appropriately selected procedure, many patients can expect to experience durable resolution of obstructive voiding symptoms.

18.5.2 Long-Term Endoscopic Management and Self Dilation

Men who have failed primary urethroplasty may be reluctant to undergo salvage reconstruction due to concerns of failure and adverse impact on urinary and sexual function. Similarly, many surgeons avoid reconstruction in a previously operated field due to fibrosis, scar, and impaired tissue healing. For most, conservative temporizing endoscopic management is not a viable long-term solution. In select cases, web like stricture recurrences with minimal spongiofibrosis at the proximal or distal extent of a substitution repair can be successfully managed with a single endoscopic dilation or internal urethrotomy [26]. Similarly, a single endoscopic dilation or internal urethrotomy has also been described as a reasonable option in failed anastomotic repair [25, 26]. In most instances, we do not recommend repetitive internal urethrotomy as evidence suggests that this only hastens scar formation, leads to increasing complexity at the time of definitive repair, and can propagate the length of an existing stricture [19].

Long-standing regimens of self-catheterization to maintain urethral patency after urethral dilation are ill-advised. Clean intermittent catheterization in the setting of neurogenic bladder appears to be well tolerated [39]. Catheterization of a diseased urethra, on the other hand, is associated with dis-

comfort, bleeding, false passage, and need for urgent intervention when self-catheterization fails [40]. For this reason, we recommend against using long-standing self-catheterization regimens as a long-term strategy for the management of urethral stricture recurrence.

18.6 Surgical Principles

Procedure selection is arguably the most important consideration in salvage repair. Tissue must be well-vascularized, scar free and supple, with resultant tension-free and water-tight anastomosis. For patients with lengthy suture lines, interposition of a well vascularized tissue flap to avoid fistula related complications should be considered.

For all urethroplasty cases, we advocate for use of optical magnification (loupes). In the event of a perineal dissection a surgical headlamp greatly improves surgeon visualization. Sharp dissection is preferred and efforts to avoid extensive cautery should be undertaken. We prefer the use of fine ceramic-coated instruments (Sontec Instruments, Centennial, CO) which provide excellent haptic feedback in scarred surgical fields and allow for precise dissection of surgical planes. A Lone Star™ (Cooper Surgical, Trumbull, CT) self-retaining retractor with sharp hooks and four-fingered scrotal rakes is an easily adaptable tool which provides excellent tissue exposure, even with deep perineal dissection. We prefer 4-0 or 5-0 polydioxanone suture for our urethral reconstruction.

Fibrin based sealants such as Tisseel (Baxter, Deerfield, IL) are useful adjuncts for tenuous repairs or lengthy suture lines where there is a risk of anastomotic leak. Oxidized regenerated cellulose, Surgicel® Fibrillar™ (Ethicon, Somerville, NJ), is an absorbable pliable bacteriostatic matrix which provides excellent hemostatic control with deep perineal dissection. Surgical drains impede convalescence and are only reserved for those patients who require early perioperative anticoagulation. To stabilize the reconstructive bed while reducing bleeding and discomfort a gentle compressive wrap (Coban™, 3M™, St. Paul, MN) is used for penile cases and a 3 inch gauze bolster is used for perineal cases.

A 16-French Silastic catheter is secured with a Stat-Lock (Bard Medical, Covington, GA) positioned low on the abdomen to accommodate for the natural anatomic curvature of the urethra while preventing undue tension on the repair. We keep this in place for 2–4 weeks with a voiding cystourethrogram performed at the time of catheter removal. Patients receive anti-cholinergic medication throughout the time of catheterization to prevent disruptive bladder spasms, which may forcefully expel urine around the catheter and compromise the repair.

18.7 Urethral Meatus

Penile fasciocutaneous skin flaps are preferred for reconstructing short (<2.5 cm) strictures involving the urethral meatus and fossa navicularis. With inadequate urethral plate, this can often be excised with primary re-approximation in the fossa navicularis. These strictures are often associated with prior urethral instrumentation or prolonged catheterization resulting in a focal ischemia-induced fossa navicularis fibrosis. With a glans sparing approach, excellent cosmesis and surgical outcomes can be achieved by tunneling the skin flap under the ventral aspect of the glans penis [41]. When utilizing adjacent tissue skin flaps, it is important to assess tissue quality, and in those with diseased penile skin alternative reconstructive options are necessary.

One such disease affecting periurethral tissue quality is lichen sclerosis or balanitis xerotica obliterans. This process is thought to be the result of chronic inflammation induced by moisture with infiltration of urine into the subcutaneous tissue leading to subepithelial fibrosis and scarring. This recalcitrant disease process often limits skin flap treatment options due to its impact on perimeatal and penile tissue quality (Fig. 18.4) [42]. In men who are plagued by lichen sclerosis-associated meatal stricture disease, an extended meatotomy (first-stage Johanson procedure) is an effective and durable option, especially in the presence of palpable disease [43]. Men must be counseled that they may experience deflection or spraying of the urinary stream and will have a hypospadiac cos-



Fig. 18.4 Extensive perimeatal and penile BXO associated with fossa navicularis and pan-penile urethral stricture. Use of penile skin for urethral reconstruction in this setting is contraindicated

metic appearance. This is generally accepted by a large portion of reoperative or elderly patients where unobstructed voiding is priority. In select men where upright voiding per urethra and fertility preservation are important, more complex single or staged substitution repairs can be considered, but have lower success rates of 75% and 79%, respectively [42]. Buccal mucosa is the preferred graft tissue in this setting. Penile skin flaps are avoided in these patients as periurethral tissue quality is often poor or involved with lichen sclerosis.

Ultimately, a perineal urethrostomy is an excellent option in men plagued with lichen sclerosis-associated recurrent urethral stricture disease with success rates >90% [42]. When the mid to proximal bulbar urethra is not involved, a loop perineal urethrostomy is associated with durable long-term outcomes in this challenging population [42, 44, 45].

18.8 Pendulous Urethra

In men who present with failed pendulous urethral stricture repair, use of substitution techniques with penile fasciocutaneous skin flaps or buccal mucosa grafts remains the preferred surgical method for definitive management. The first critical step in salvage repair of pendulous urethral strictures is ensuring that the entire stricture has been incised, with the urethrotomy extending into healthy urethra proximally and distally. An effort should be made to resect all residual scar, fibrosis, and hair-bearing tissue from the prior repair to increase the likelihood of success [6]. Urethral patency is affirmed by passing at least a 24-French Bougie sound proximally and distally without resistance prior to securing the graft or flap in place.

While various penile skin flaps have been described and are effective [46, 47], we prefer a circular or longitudinal penile skin flap as described by McAninch [48] and Orandi [47] (Fig. 18.5). These versatile flaps utilize the redundant and hairless penile skin. All penile fasciocutaneous flap techniques are supplied by a delicate vascular pedicle composed of the anterior lamella of Buck's fascia and the vascular arcade layer of the tunica dartos; we caution the use of this technique in men with clinically significant microvascular disease.

When there is a lack of genital skin, such as those with multi-reoperative hypospadias, buccal mucosa is the preferred graft tissue. Buccal mucosa relies on vascular ingrowth from the operative bed, it is therefore imperative that all scarred and poorly vascularized tissue is excised to ensure adequate graft support in the salvage setting. When buccal

mucosa is unavailable from prior repairs, lingual or rectal mucosa grafts can be used but are generally thinner and less robust [49–52]. Repeat buccal mucosa harvesting is not only challenging, but can be associated with oral morbidity and poor graft neovascularization in a reoperative field. Graft position can be variable, but equally effective, and is based on surgeon preference. We prefer a ventral onlay technique as this limits excessive urethral dissection and further impairment to an already compromised tissue field. For ventral grafts, it is important to ensure healthy and adequate spongiosum. In the penile urethra, this is occasionally deficient and therefore requires a multilayer closure of Buck's fascia and tunica dartos (pseudospongiosoplasty). In cases of lengthy pendulous repairs, or when closure of the spongiosum may not be possible, a tunica vaginalis flap, harvested via a scrotal counter incision, is a useful adjunct for ventral graft vascular support (Fig. 18.6).

Assessment of the urethral plate should be performed prior to securing a graft or flap in



Fig. 18.5 Penile fasciocutaneous skin flap configurations for penile urethral stricture reconstruction. (a) Circular penile skin flap (McAninch technique)

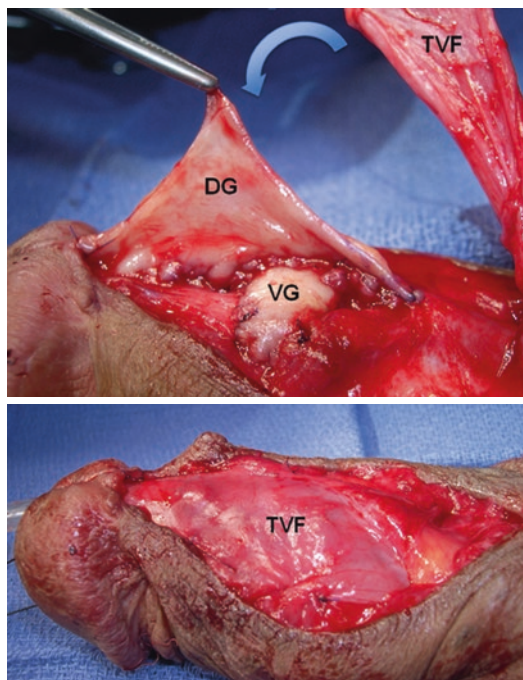


Fig. 18.6 Complex salvage reconstruction of distal penile urethral stricture with urethral plate excision, dorsal buccal mucosa inlay, ventral graft onlay, and tunica vaginalis flap overlay. DG dorsal graft, VG ventral graft, TVF tunica vaginalis flap

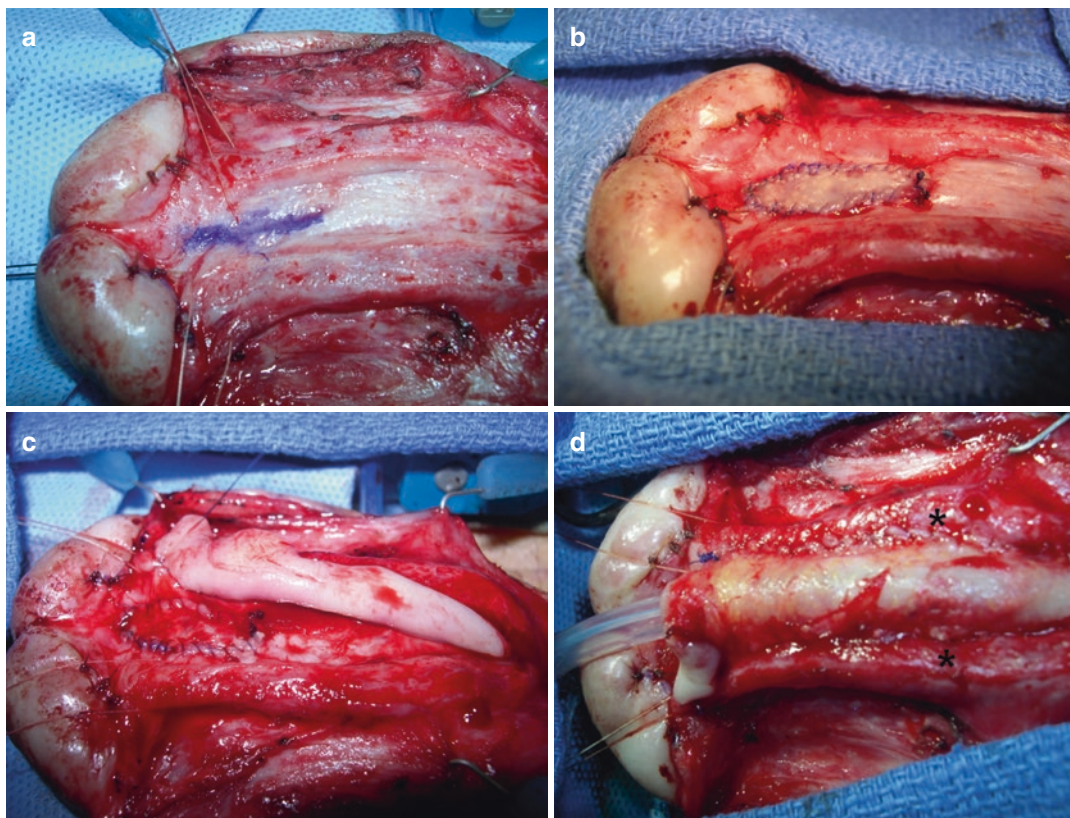


Fig. 18.7 Urethral plate salvage with overlapping dorsal and ventral buccal mucosa grafts. (a) Inadequate distal urethral plate (blue line) for primary graft ventral onlay, (b) Urethral plate incision and dorsal buccal mucosa graft

inlay, (c) Combined with ventral buccal mucosa graft onlay, (d) Completion of ventral graft anastomosis with healthy surrounding spongiosal tissue (asterisk*) for primary closure

place. In general, a urethral plate less than 1 cm in width is inadequate. A deficient urethral plate can be augmented by performing a single stage incision or excision of the scarred plate with dorsal buccal mucosa graft inlay and a synchronous ventral graft onlay or penile flap as these have been associated with favorable results (Fig. 18.7) [53]. Flap tubularization is an alternative option, however, single stage tubularized graft placement is not recommended.

For men with lengthy obliterative, or near obliterative, recalcitrant penile urethral strictures, and a lack of healthy periurethral tissue, a staged urethroplasty with buccal mucosa graft, or meshed split thickness skin graft, or perineal urethrostomy are viable treatment options. In very select cases of short segment (0.5–1 cm) obliterative proximal penile urethral strictures, focal excision with proximal bulbar urethra mobiliza-

tion and primary anastomosis can yield satisfactory cosmetic and functional results [54]. In general, however, lengthy excision and primary anastomosis is not recommended in the pendulous urethra as this can lead to significant penile shortening and ventral curvature.

18.9 Bulbar Urethra

18.9.1 Mid to Proximal Bulbar Urethra

Excision with primary end-to-end anastomosis (EPA) is the preferred management option for recurrent post-urethroplasty bulbar urethral stricture disease. We have found that approximately one-half of graft or flap repairs have short (<3 cm) strictures. In this setting, salvage anastomotic ure-

throplasty success rates rival primary anastomotic repairs [12]. The decision to perform EPA in the salvage setting should not rely solely on the length of the stricture; rather, it should be based on the principle of successfully achieving a tension free anastomosis between healthy well-vascularized proximal and distal bulbar urethral segments. In our practice, we have been able to successfully perform EPA with defects approaching 5 cm in length in men with favorable anatomy and tissue quality [55]. We utilize a “mid-bulbar” rule – strictures most amenable to anastomotic urethroplasty are those located proximal to the midpoint of the perineal bulb. This is facilitated by the natural elastic properties of the mobilized proximal and distal bulbar urethra, allowing the surgeon to bridge the gap of the excised segment in a tension-free manner without excess penile tethering. Adequate stretched penile length (>14 cm) and stricture location (proximal half of perineum) are favorable for extended EPA (Fig. 18.8) [55, 56].

Transmural fibrosis is best addressed through judicious but complete excision. However, many strictures may exceed the limits of urethral mobilization and tension-free primary anastomosis, prompting consideration of augmented substitution urethroplasty with or without partial excision of a diseased segment of urethra. If EPA alone is not an option, grafts can be used with relatively good success. We prefer buccal mucosa in this setting. A thorough assessment of the spongiosum should be undertaken as this will guide placement of the graft. While we prefer a ventral onlay, dorsal or one-sided inlay can be used as an adjunct when the spongiosum is diseased or deficient [57]. Success appears to be similar among different salvage substitution approaches and it is often necessary to tailor based on patient and tissue related factors [58].

18.9.2 Distal Bulbar Urethra

In select men, focal (<2 cm) urethral strictures of the distal bulbar urethra may be amenable to anas-

tomotic urethroplasty. However, lengthy (>2 cm) strictures in this location often require substitution techniques to avoid excessive anastomotic tension [6]. For obliterative strictures, all scar must be excised to achieve successful graft embedment. An augmentation technique combining buccal graft with a partial anastomosis can be used in the bulbar urethra for strictures that are lengthy and obliterative but not amenable to EPA – effectively termed augmented (substitution) anastomotic urethroplasty [59]. In this setting, we prefer a dorsal graft onlay combined with ventral spongiosum sparing end-to-end urethral anastomosis which can bridge defects up to 3 in length. For non-obliterative strictures (>2 cm), we prefer a ventral onlay buccal mucosa graft when there is adequate spongiosum. In the case of significant spogiofibrosis, a dorsal inlay or onlay can be used. Flaps are typically avoided in this location primarily due to the extensive dissection required to advance a penile flap into the perineum which can lead to penile shortening or ventral tethering [60].

18.9.3 “Loop” Perineal Urethrostomy

The extent of urethral scar and lack of available uncompromised tissue may ultimately limit options for reconstructive success, prompting discussion of perineal urethrostomy. Perineal urethrostomy remains an excellent option associated with a high quality of life for patients with unfavorable urethral pathology suitable for reconstruction, or for those who do not desire extensive surgery. Contraindications to perineal urethrostomy include extensive disease proximal to the bulbomembranous junction, such as prostatic urethral stenosis and bladder neck contracture [61]. In our practice, we prefer use of a loop perineal urethrostomy via midline longitudinal perineal incision with perineal skin advancement via a “7” flap or z-plasty configuration when necessary (Fig. 18.9) [62]. The urethrostomy matured to

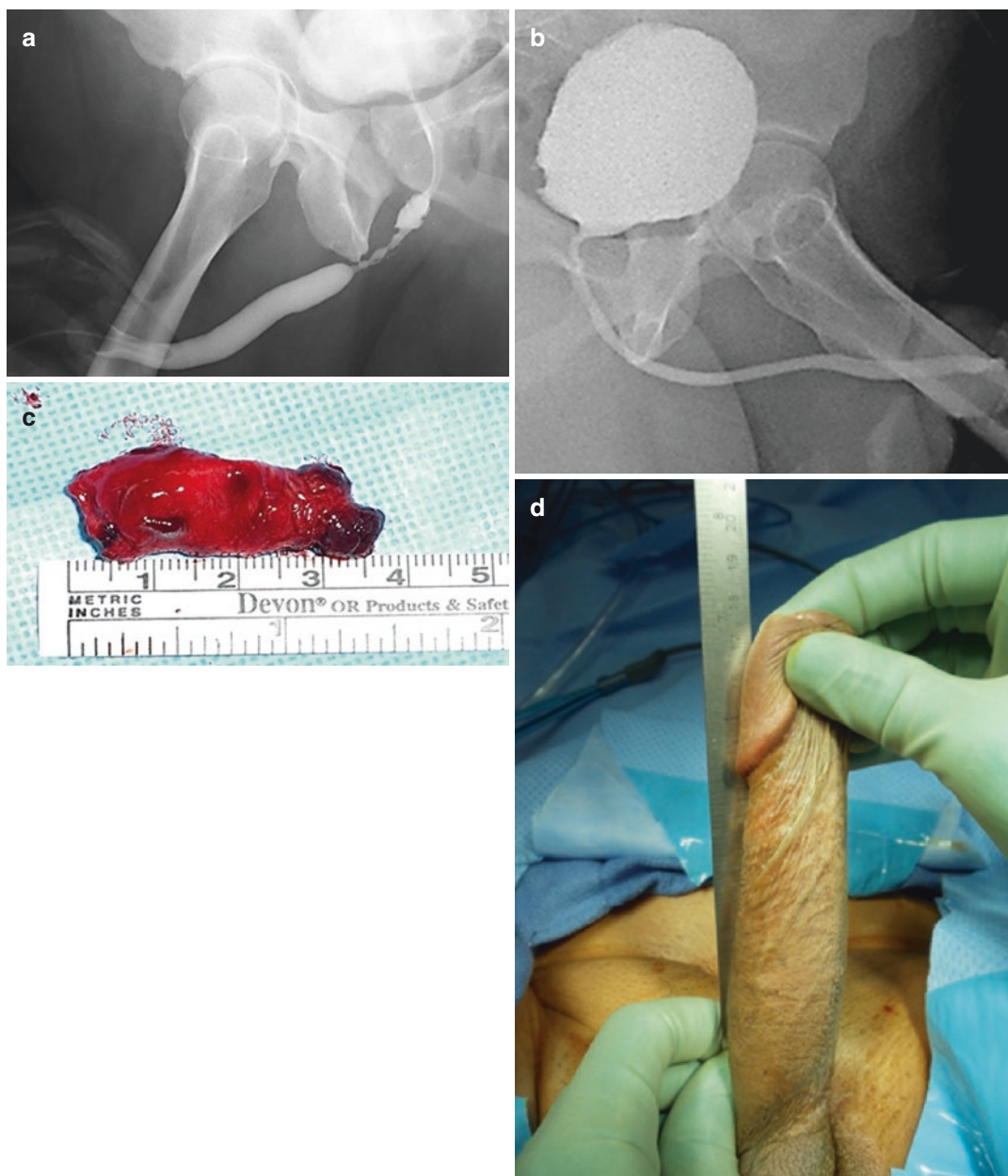


Fig. 18.8 Recurrent mid to proximal 4 cm bulbar urethral stricture following penile skin graft (a) reconstructed with complete excision and reanastomosis (b and c), preoperative stretched penile length 17.5 cm (d)

the perineal skin should be no less than 4 cm in length. Preservation of the dorsal urethral plate and antegrade blood supply via the bulbar artery complex minimizes urethrostenosis

[45]. This standardized and versatile approach allows for a stepwise escalation in urethral stricture management pending intraoperative findings.

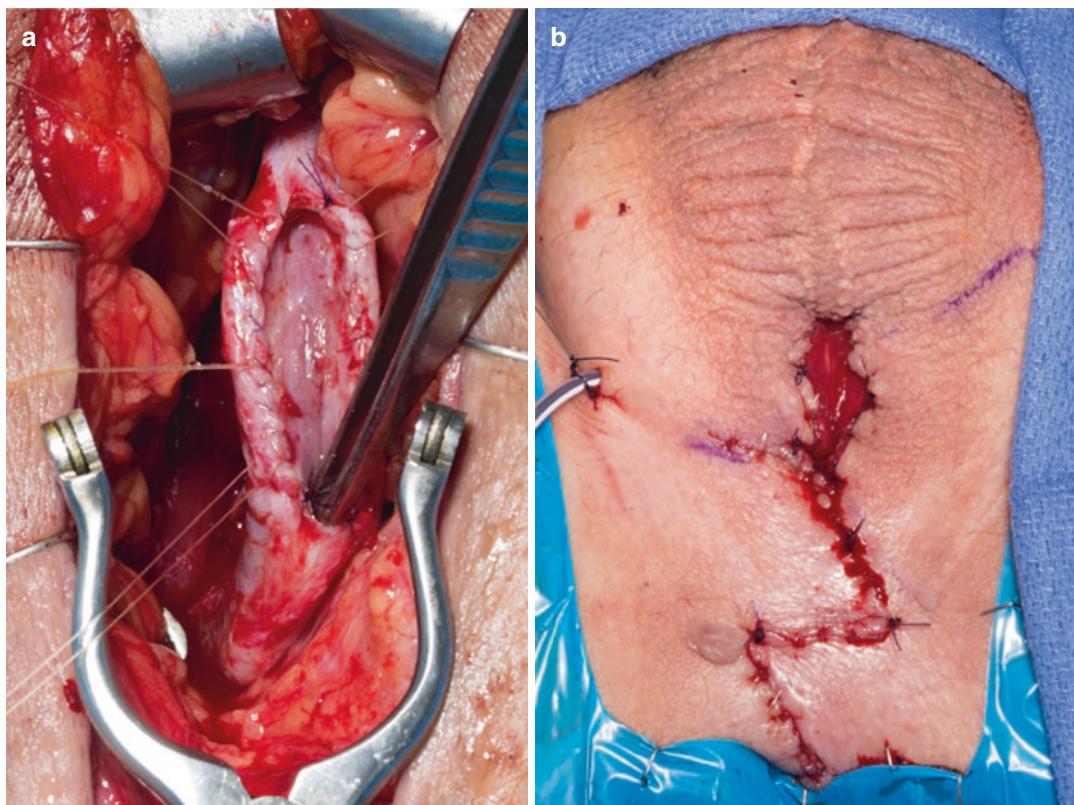


Fig. 18.9 Loop perineal urethroplasty via midline perineal incision (**a**) preservation of the posterior urethral plate and antegrade blood supply through the corpora

spongiosum after complete bulbar mobilization with 5 cm urethroplasty, (**b**) z-plasty advancement skin flap closure posterior to loop urethroplasty to reduce skin tension

18.10 Conclusion

Revision urethroplasty is an effective treatment option for recurrent stricture after failed anterior urethroplasty. Success rates of revision urethroplasty rival primary repairs. While a single attempt at endoscopic management can be utilized for select cases, it is not considered a viable long-term solution. The majority of men will require substitution techniques, excision with primary end-to-end anastomosis or perineal urethroplasty depending on the length, location and severity of the stricture. In general, substitution techniques are preferred for recurrent strictures of the pendulous urethra while excision with primary end-to-end anastomosis remains the preferred management for recurrent bulbar urethral strictures in the mid and proximal bulbar urethra. For men with unfavorable pathology or for those

who do not desire extensive surgery, loop perineal urethroplasty is an excellent salvage technique.

18.11 Preferred Surgical Instruments

- Ceramic-coated scissors (Sontec Instruments, Centennial, CO)
 - Metzenbaum (1200-915)
 - Iris (1200-764)
- Gerald toothed forceps (Sontec Instruments, Centennial, CO – 140-372)
- DeBakey vascular forceps (Sontec Instruments, Centennial, CO – 2200-109)
- Angled DeBakey vascular clamps (BD Technologies, V. Mueller, Minneapolis, MN – CH6098)

- Beckman-Weitlaner self-retraining retractor (5.5 inches) (Millennium Surgical, Narberth, PA – 0-52530)
- Lone Star™ (Cooper Surgical, Trumbull, CT) self-retaining retractor (3304G)
 - 5-mm sharp hook (3111-1G)
 - 12-mm blunt hook (3350-1G)
 - 4 prong blunt rake (3334)
- Olive-tipped bougie a boulé sounds (GU4005-018, 020, 022, 024, 026, 028, 030)
- 4-0 and 5-0 polydioxanone suture for anastomosis
- Tisseel (Baxter, Deerfield, IL)
- Surgicel® Fibrillar™ (Ethicon, Somerville, NJ)
- 16-French Silastic® catheter (Bard Medical, Covington, GA) (33616)
- Stat-Lock (Bard Medical, Covington, GA) (FOL0102)

Key Summary Points

- Precisely characterizing the location, length, density, and diameter of the recurrent stricture with retrograde urethrogram, voiding cystourethrography, and/or cystourethroscopy is imperative prior to any salvage repair
- A *single* attempt at endoscopic management can be utilized for stricture recurrences after substitution or anastomotic repair when there is minimal spongiofibrosis
- For most patients with recurrent urethral stricture disease, conservative temporizing endoscopic management is not a viable long-term solution
- Extended meatotomy is a reasonable option for men plagued by recalcitrant meatal or fossa navicularis strictures
- Substitution techniques including penile skin flaps or buccal mucosa grafts are preferred for recurrent strictures of the pendulous urethra. Careful assessment of surrounding penile skin is necessary if considering a flap

- In general, obliterative strictures should be completely excised. In the case of focally severe strictures within longer defects or penile urethra location, a single-stage urethral plate salvage can be performed with a dorsally placed buccal mucosa graft combined with an overlapping penile skin flap or buccal mucosa graft onlay
- Excision with primary end-to-end anastomosis (EPA) is the preferred management for recurrent bulbar urethral stricture disease involving the mid and proximal bulbar urethra
- If anastomotic urethroplasty is under excessive tension, the defect (<3 cm) can be augmented by a dorsal or ventral buccal mucosa graft onlay combined with a 2-layer closure of the ventral spongiosum
- A loop perineal urethrostomy with preservation of the dorsal urethral plate is a simple and effective option for non-obese patients with unfavorable pathology suitable for reconstruction or for those who do not desire extensive surgery

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Surgical Reconstruction of Male Urethral Diverticulum and Megalourethra

19

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19.1 Introduction, Pathogenesis and Diagnosis

Diverticula of the male urethra are fairly uncommon abnormalities. They are localized periurethral cavities with a communication to the urethral lumen and can be divided into congenital and acquired or primary and secondary [1, 2]. Acquired UD are far more common than the congenital type, accounting for 67–90% of all UD [3, 4].

Congenital Urethral Diverticula They are urothelial-lined sacculations resulting from either a dilatation of a segment of the urethra or the attachment of a residual embryological structure to the urethra by a narrow communication or from incomplete urethral ventral wall/spongiosal development similar to an incomplete hypospadias [5–7]. Another possible cause was advocated by Huter in the 1860s and later by Kaufmann in 1886 to which a congenital anterior urethral valve contributed to the development of a congenital diver-

ticulum by obstruction and increase of pressure in the lumen [4, 8, 9]. Another possible etiology suggested was an intraspongiosal hematoma induced by urethral trauma, creating to a paraurethral space [10]. It has also been suggested that congenital UD may represent giant cystic dilatation of Cowper ducts, although other authors do not favour this etiology due to a more distal location of the Cowper ducts [11]. The mechanism by which congenital diverticula might develop from periurethral cysts with spontaneous rupture into the urethra was originally proposed by Elbogen in 1886 and later by Johnson, the latter suggesting that these cysts arose from obstructed or abnormal periurethral glands [12, 13]. Süter in 1908 postulated that these cysts arose from epithelial cell nests that remained after closure of the urethral folds [14]. This theory as well as Voillemier's theory were supported by the constant ventral midline position of the diverticulum opening. Because each of these theories of congenital diverticulum formation have a plausible embryologic basis, clinical correlation and proponents, it is assumed that according to our present knowledge congenital diverticula may result from multiple factors, especially either faulty closure of the urethral folds or persistent epithelial remnants (Table 19.1). This has led to problems of the definition of UD and some are mislabeled as related congenital anomalies [8]. Therefore, treatment has largely been individualized. Some authors stated that congenital diverticular walls lack supportive corpus spongiosum tissue, are lined by urethral epithelium and are surrounded by a flimsy fibrous

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Table 19.1 Theories on embryogenesis of congenital urethral diverticula

Voillemier [5]	Deficient development of spongiosum representing incomplete course of hypospadias
Huter [8]	As a result of distal obstruction
Kaufmann [8]	Distal obstruction associated with defective fusion of urethral segments
Elbogen [12] and Johnson [13]	Obstructed or blind-ending periurethral Cowper glands ruptured into urethral lumen
Süter [14]	Originating in cystic epithelial cell nests trapped in periurethral tissue during closure of urethral folds

Cited by Boissonnat and Duhamel [8]

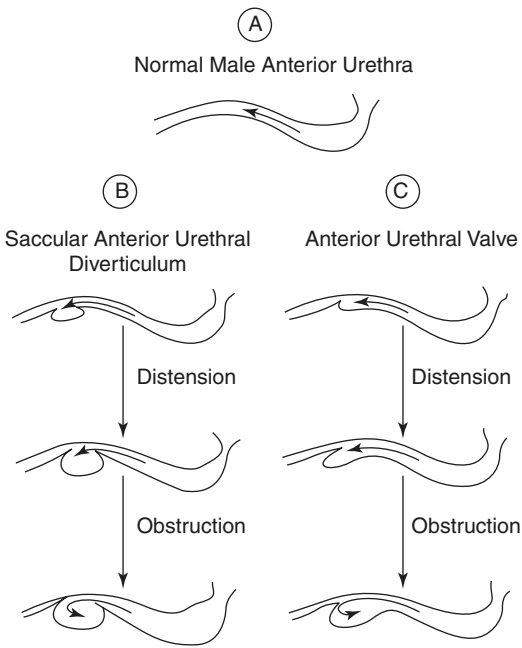


Fig. 19.1 Two postulated mechanisms for explaining urinary obstruction due to anterior urethral diverticula in children. (Reproduced with permission of Kirks et al. [44])

capsule [8, 9]. Other authors observed that all of their patients treated by an open surgical approach had intact overlying corpus spongiosum and were epithelialized [3, 4, 15]. At present, congenital UD are thought to be secondary to an obstructing valve, lack of supporting corpus spongiosum, defective closure of urethral folds, rudimentary urethral duplication and ectopic cloacal epithelium (Fig. 19.1).

Typically, congenital diverticula occur in the anterior urethra, near the penoscrotal junction, are lined by urethral mucosa and may present as saccular or globular/tubular outpouchings of the ventral urethral wall. Saccular diverticula lack true necks, are located ventrally from the bulbous to the mid penile urethra and are associated with urinary obstruction potentially leading to proximal urinary decompensation, according to Firlit’s classification of types I to IV [9, 16]. The globular diverticula, the least common, are located more proximally in the bulbous urethra and are more associated with complications of urinary stasis due to absent contractility of the diverticulum wall, such as infection and stone formation. Clinically, they may present with microscopic or gross hematuria, severe voiding obstruction and/or irritative urinary complaints. Diagnostic evaluation must include a retrograde urethrogram and voiding cystourethrogram or cystourethros-copy. Without careful and meticulous diagnostic evaluation, a less experienced examiner may be induced into an erroneous diagnosis.

Acquired Urethral Diverticula These are the most commonly encountered lesions in males, accounting for more than 90% of all diverticula in this gender, and even more frequently in women, probably due to complications of child-birth and the more common occurrence of periurethral abscesses. In the international literature, acquired UD occur far more commonly than the congenital variant, accounting for 67–90% of all UD [4, 17, 18]. In men, they also develop after periurethral suppuration and abscess formation secondary to infection of the periurethral glands, prostate or surrounding hematoma. Other causes include obstruction related to urethral stricture or an impacted urethral calculus, a Cunningham clamp or condom penile sheaths commonly used in paraplegics, urethral trauma and for post-prostatectomy incontinence. Other less frequent causes have been described, such as after an abdominoperineal pull-through operation for an imperforate anus and after placement of an artificial urinary sphincter [19, 20]. Risk factors for acquired UD include periurethral abscess, infection, blunt trauma, urethral stricture, and urethral

Table 19.2 Risk factors for development of acquired UD

Periurethral abscess
Recurrent infection
Blunt external trauma
Urethral stricture
Urethral calculi
Prior hypospadias surgery
Prior anterior urethroplasty
Chronic indwelling urethral catheterization
Traumatic urethral instrumentation

UD urethral diverticula

calculi [3, 4, 17, 21] (Table 19.2). Acquired UD can occur in any urethral segment. They are lined by septic granulation tissue and, rarely by epithelium. Their walls do not possess muscle fibers.

Clinical manifestations of UD are related to the enlarging, fluctuant swelling or cavity leading to urethral obstruction and urinary stasis and, consequently, suppurative infection and stone formation (Table 19.3) (Fig. 19.2). While congenital diverticula often remain asymptomatic until complicated by infection or a stone, clinical presentation of acquired diverticula depend largely on size. As the diverticulum increases in size, the patient may notice urinary involuntary dribbling, recurrent urinary tract infection, a weak stream of urine, a palpable swelling in the urethra in the penoscrotal or perineal regions after voiding, hematuria and pain. Some patients have a history of exposure to repeated instrumentation or long-term indwelling catheters, especially in spinal cord injury patients, or prior surgical repair of hypospadias or urethral stricture disease [18, 21–23]. Other clinical situations that led to the diagnosis of a urethral diverticulum included urinary retention, urethral stricture urethrocuteaneous fistula and inability to perform urethral catheterization [24]. Physical examination may reveal a palpable penoscrotal mass, swelling and rarely an urethrocuteaneous fistula orifice that may suppurate with compression. Most often, general physical and local examination do not reveal any significant and conclusive findings.

While it is well accepted that the gold standard for diagnosing female UD involves magnetic resonance imaging, the diagnostic yielding of this

Table 19.3 Clinical manifestations of UD and magalourethra

Post-void dribbling/urinary incontinence
Dysuria
Urethral bleeding
Urinary frequency
Recurrent UTI
Weak stream
Penoscrotal mass
Incomplete emptying
Urethral stricture
Urethrocuteaneous fistula
Urethral calculus

UD urethral diverticula, *UTI* urinary tract infection



Fig. 19.2 Giant penoscrotal urethral diverticulum sac opened with calculi

imaging modality has not been superior to fluoroscopic modalities, such a retrograde urethrogram and voiding cystourethrogram in conjunction with urethral ultrasonography, which provide excellent details of UD [24–26]. These imaging studies provide exact location of the diverticulum, volume, neck size and other associated urethral abnormalities (Table 19.4) (Figs. 19.3, 19.4 and 19.5). Flexible cystourethroscopy should also be performed to rule out urethral stricture, impacted stones, erosion and potentially associated secondary malignancy. Endoluminal ultrasonography has been reported to be a potentially useful imaging modality but the majority of patients evaluated were women [27].

Megalourethra It is defined as a congenital urethral anomaly consisting of a diffuse enlargement of the anterior urethra. There are reports that describe

Table 19.4 Diagnostic imaging modalities

	Advantages	Disadvantages
RUG/VCUG	Technically easy Diagnosis of simple diverticula and calculi	Ionizing radiation and urethral catheterization Suboptimal results for neoplasms and complex diverticula
CT	Diagnosis of urethral calculi and staging of urethral neoplasms	Ionizing radiation, urethral catheterization and patient discomfort Suboptimal results for neoplasms and complex diverticula
Endoluminal US	No ionizing radiation or urethral catheterization lowering risk of UTI	Operator dependent
MRI	No ionizing radiation or urethral catheterization lowering risk of UTI Diagnosis and characterization of urethral/periurethral pathologies	Expensive and not universally available

RUG/VCUG retrograde urethrogram/voiding cystourethrogram, *CT* Computerized tomography, *US* ultrasound scan, *MRI* magnetic resonance imaging

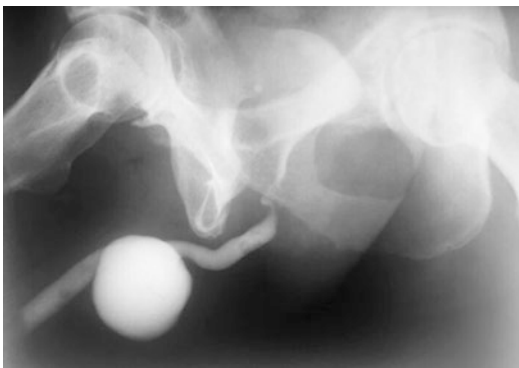


Fig. 19.3 Bulbar urethral diverticulum due to endoscopic instrumentation in a 47 year-old man

an acquired form of megalourethra or megaurethra. The acquired form is a potential complication of flap urethroplasty in which distal obstruction leads to proximal dilatation of the reconstructed urethra [28]. The term megalourethra generally refers to a congenital anomaly of the anterior segment of the urethra and was first reported by Nesbit in 1955 [29]. It is a rare congenital mesenchymal disorder of the male anterior urethra characterized by a nonobstructive dilatation of the penile urethra [30, 31]. Nesbitt in 1955 defined it as “a congenital dilatation of the penile urethra without distal obstruction”. Less than 100 cases have been reported in the literature until now [31, 32].



Fig. 19.4 Bulbomembranous urethral diverticulum developed after restructure of distal anastomosis following fasciocutaneous flap neotubularized urethroplasty in a 49 year-old man with a 9-cm urethral defect due to ischemic bulbar necrosis

In 1963, Dorairajan classified congenital megalourethra into two types based on findings of urethrography: a scaphoid type and a fusiform variety [33]. The scaphoid type is more common, and although usually less severe, is associated with a deficiency of the corpus spongiosum and presents as a bulging of the ventral urethra (Fig. 19.6). The corpora cavernosa are intact and children with scaphoid megalourethra are able to achieve erections. Characteristic ballooning of the ventral urethral sacculation usually occurs during micturition and often leads to urine retention within the dilated urethral segment and, consequently, post void dribbling. The fusiform megalourethra is characterized by deficiency of both the corpus spongiosum and corpora cavernosa. This is a more severe variant

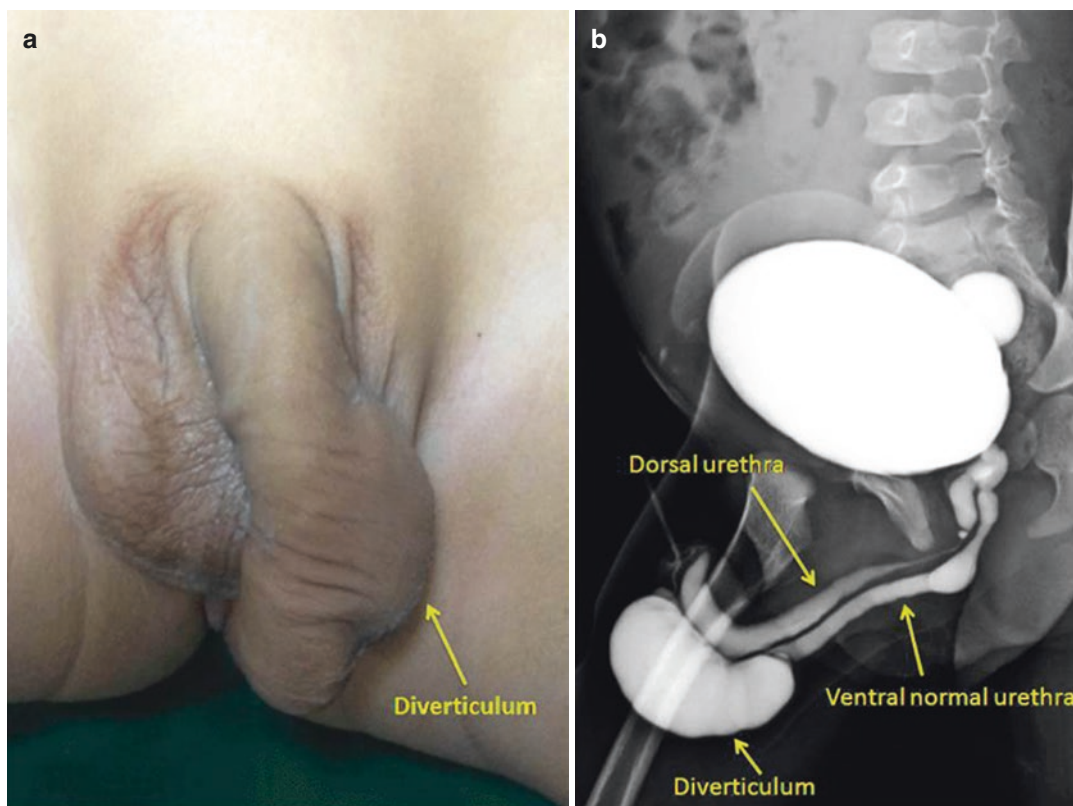


Fig. 19.5 (a) Clinical photograph of urethral diverticulum at distal penile urethra; (b) Voiding cystourethrogram showing complete urethral duplication and the distal ven-

tral urethral diverticulum in a sagittal plane in the same patient. A small bladder diverticulum is also evident. (Reproduced with permission of Shah et al. [46])



Fig. 19.6 Megalourethra in a 6 month-old male child

of megalourethra which presents as a circumferential expansion of the urethra in an elongated and sack-like penis. Erections are not possible with this variant. However, in 1986 Appel et al.

reviewed several cases of megalourethra with histologic evaluation and demonstrated that there was variable atresia of the corpora cavernosa [34]. They concluded that the classification of megalourethra into scaphoid and fusiform types was somewhat arbitrary, and suggested that megalourethra should be recognized as a disorder with a spectrum of presentations.

The exact etiology and embryological pathway of congenital megalourethra is controversial and unclear. The most commonly accepted theory proposes a mesodermal dysplasia of the phallus as a potential cause [31]. Another assumption is that delayed or deficient canalization of the glandular urethra may be associated with deficient development of the corpus spongiosum and corpora cavernosa, which would lead to defective support of the urethra and would cause functional obstruction [35, 36]. These theories

are supported by the observations that megalourethra is often associated with other congenital anomalies, especially of the genitourinary tract. Approximately 50% of patients with scaphoid megalourethra also suffer from the prune belly syndrome [37]. Several other associated anomalies have been described, such as hypospadias, posterior urethral valves, vesicoureteral reflux, renal dysplasia, imperforate anus, vesicorectal fistula, vertebral anomalies and cardiac congenital defects [38]. Fusiform megalourethra is most commonly associated with non-urological disorders and renal insufficiency resulting from renal dysplasia is common. The prognosis is dismal. In a review by Jones et al., associated congenital anomalies are seen in 80% of scaphoid type and 100% of fusiform type megalourethra [31].

The diagnosis of megalourethra is made by physical examination of the external genitalia as well as imaging studies, such as retrograde urethrogram and/or voiding cystourethrogram which demonstrate the typical urethral dilatation. However, the full workup should also include renal function tests and imaging of upper and lower urinary tracts. The status of upper urinary tract will determine the ultimate outcome.

Differential diagnosis between congenital and acquired diverticula, megalourethra and other urethral anomalies mimicking the ones mentioned above, such as urethral atresia, a web, and urethral duplication should be considered.

19.2 Treatment and Complications

The majority of the UD in men are asymptomatic and do not require treatment. The goals of treatment of symptomatic lesions are: (1) relief of distal obstruction, (2) control of infection, (3) removal of all stones and other foreign bodies inside the diverticulum, (4) diverticulectomy and (5) urethral reconstruction. Treatment can be standardized depending on the size of the cavity, thickness of the dorsal wall and the integrity of the corpus spongiosum or other adequate sup-

Table 19.5 Treatment options for UD and megalourethra

A. Endoscopic
Simple transurethral unroofing
B. Open approaches/procedures
Open marsupialization
Infolding urethral plication
Open directiculectomy and urethroplasty w/ overlapping periurethral flaps
Open diverticulectomy w/ventral graft onlay substitution urethroplasty
Urinary diversion

UD urethral diverticula, UTI urinary tract infection.

porting tissue layers (Table 19.5). The lack of bulging with micturition can be used as evidence of the anatomical integrity of the corpus spongiosum which may allow simple transurethral unroofing. This minimally invasive procedure results in the least traumatic and least expensive treatment modality. It can be performed with use of the Bugby electrode, a resectoscope cutting stylet or a valvotome as described by Mahony [39]. However, some do not believe that endoscopic treatment is not curative and carries a likelihood of failure and the need for reoperation [24]. There is also a risk of urethrocutaneous fistulation [4]. Others recommend caution, or simply do not advise endoscopic treatment at all when a large draining cavity is likely to persist or when the urethral wall is too thick to incise adequately [40]. The lesions that penetrate the spongiosum and lack adequate support, have large draining cavities or possess thick anterior urethral walls are best treated by open single-stage or multistage surgical reconstruction. When symptoms result from stagnation of urine in a small-mouthed diverticulum, open marsupialization can be attempted. In patients who underwent prior urethral surgery and have an increased risk of compromised adjacent tissue support, integrity and scarring, open diverticulectomy and urethral reconstruction with overlapping periurethral flaps or ventral graft onlay substitution urethroplasty should be considered [4, 21, 24] (Fig. 19.7).

The initial treatment of megalourethra should include suppressive broad-spectrum antibiotics,

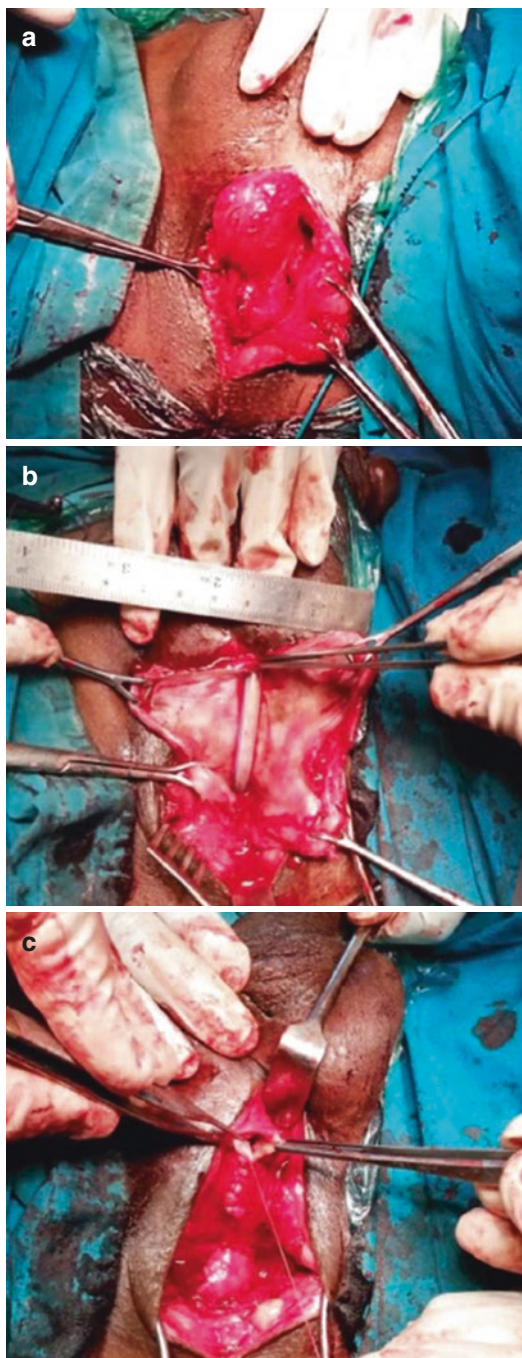


Fig. 19.7 (a) Intraoperative images showing large diverticulum. (b) Intraoperative images showing large diverticulum which was laid open. (c) Intraoperative images showing excess diverticular wall which was excised and primary reduction urethroplasty performed. (Reproduced with permission of Thakur et al. [45])

especially when upper tract anomalies coexist [41]. Surgical intervention should be considered if the overall prognosis is good. Surgical reconstruction may also be one-stage or multiple-stage urethroplasty depending on the age of presentation and general condition of the patient. Patients with scaphoid megalourethra do not always need surgery. If minimal post void dribbling is the only complaint, this can be managed with milking of the urethra after urination to drain retained urine. In isolated scaphoid type megalourethra, reduction urethroplasty after degloving and mobilization of penile shaft skin is the most commonly used repair and gives excellent results [29, 32, 42]. However, Heaton et al. described a successful alternative procedure using infolding urethral plication rather than excision [43]. After penile degloving, Lembert sutures are placed ventrally in a vertical row 2–3 mm apart. Potential advantages reported were better preservation of urethral vascularization and a lower incidence of urethrocutaneous fistulation.

Posterior UD that are refractory to endoscopic treatment can be approached perineally but apparently are best treated with a transabdominal procedure.

Urinary diversion can be a suitable option for patients with neurogenic bladder dysfunction, especially in those performing intermittent urethral self-catheterization, as well as for those with unreconstructable urethras due to multiple surgeries, severely compromised urethras or extensive fibrosis from prostatic or pelvic irradiation.

Complications of surgical treatment of UD and megalourethra are similar to those related to any type of urethral reconstruction, the most common being urinary tract infection, abscess formation, recurrent diverticulum, urethral stricture and urethrocutaneous fistulation.

19.3 Conclusions

UD and related anomalies are relatively rare in males. The cause, classification and pathogenesis of UD and other related urethral anomalies remain controversial, multifaceted and somewhat

confusing. These lesions usually pose challenges in diagnosis and reconstruction and require a high index of suspicion. Retrograde and voiding cystourethrograms provide excellent results in the diagnostic workup and useful information for treatment planning. Asymptomatic patients may not require treatment and may be approached conservatively with close surveillance. Surgical intervention is recommended for symptomatic or larger UD and megalourethra, particularly complicated with infection or calculi. Open diverticulectomy and urethral reconstruction in one or multiple stages should be planned according to the individual characteristics of the patient and disease. Urinary diversion may be a suitable and necessary option for complex patients with neurogenic lower urinary tract dysfunction who need intermittent self-catheterization for bladder drainage.

Key Summary Points

- An urethral diverticulum may be defined as a localized outpouching from the urethra into a potential periurethral space
- UD may be congenital (seen only in males) or acquired with an incidence of approximately 10% and 90%, respectively
- Embryogenesis and pathogenesis are unclear
- Risk factors for the development of acquired UD have been determined, such as infection, external blunt trauma, traumatic urethral instrumentation, urethral stricture, prior anterior urethral surgery, chronic indwelling urethral catheterization, urethral calculi and neurogenic bladder dysfunction
- Although rare in general, UD are more common in females than in males
- Symptoms are variable and a high index of suspicion is necessary
- Retrograde urethrogram and voiding cystourethrogram in conjunction with urethral ultrasonography provide excellent details of male UD, are cost-

effective and should be considered gold standard in the diagnostic workup

- Megalourethra, a congenital mesenchymal disorder of the anterior urethra, consists of a diffuse enlargement of the anterior urethra. There are two types: scaphoid (more common and less severe) and fusiform
- The majority of UD and megalourethra in men may be asymptomatic and do not require treatment
- The goals of treatment of symptomatic UD are to relieve obstruction, control infection, remove all stones and other foreign bodies inside the diverticulum, excise the diverticulum and reconstruct the urethra
- Urinary diversion can be a suitable option in complex patients, such as those with a neurogenic bladder, patients with severely compromised or devastated urethras due to prior multiple surgeries or extensive fibrosis from prostatic or pelvic irradiation

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Surgical Reconstruction of Urethrocutaneous Fistulae

20

Margaret M. Higgins and Shubham Gupta

20.1 Introduction

A urethrocutaneous fistula is an abnormal epithelialized tract connecting the urethra to the skin. Urethrocutaneous fistulae (UCF) present a challenging reconstructive problem. Often presenting in previously operated upon or otherwise compromised tissues, their management should be individualized to the clinical scenario to achieve optimal outcomes. It is helpful nonetheless to classify and stage UCF on their location, etiology, health of surrounding tissues, and have a patient-focused view of the objectives of intervention.

20.1.1 Location

Urethral fistulae can be broadly divided into posterior and anterior urethral locations. This is important as posterior fistulae such as rectourethral fistula are managed with a different set of principles and techniques, and often in a multidisciplinary fashion. Posterior fistulas are covered elsewhere in the book, and will not be further addressed in this chapter. Anterior UCF may present anywhere along the course of the anterior urethra and may be perineal, scrotal or penile in

skin location. If a repair is feasible, the location of the fistula within the urinary tract as well as the skin help dictate the strategy.

20.1.2 Etiology

Previous surgery is the leading cause of UCF. The incidence of UCF following hypospadias repair ranges from 6.2% to 38.8% [1, 2]. The majority occur in the first year after hypospadias repair, however, up to 25% are found more than 2 years after repair [3]. In a cohort of 166 patients who underwent various types of urethroplasties, 3 patients developed a UCF within the 15-year follow-up [4]. Urine extravasation early after urethroplasty is best thought of as a urine leak rather than a fistula, as it will likely resolve with a few extra days of catheter drainage. UCF are uncommon after an uncomplicated single stage anterior urethroplasty, even if it is augmented with tissue transfer. However, the rates are slightly higher after the second stage of a staged urethroplasty. In a series of 35 patients treated with two-stage urethroplasty, five developed UCF, three within 5 years of surgery and two under 10 years [5].

Extensive urethral strictures with proximal fistulation can develop a “watering can” perineum, an epithet describing the fluoroscopic appearance of multiple urethroperineal fistulae [6] (Fig. 20.1). Often, the underlying pathology is a stricture that has been neglected or inadequately

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Fig. 20.1 A retrograde urethrogram demonstrates a ‘watering-can perineum’ – multiple urethrocuteaneous fistulae arising from a mid-bulbar location. A long bulbar narrowing distal to the fistulous origin is noted. This patient was treated with a two-stage urethroplasty

managed with delayed and recurrent dilations, with long intervening periods of smoldering inflammation and overt infections. Gonorrhea is classically the culprit – in one African study of 216 patients, 44 had watering-can perineum, 82% of whom had a history of gonococcal infection [7] – however, schistosomiasis, tuberculosis, and Crohn’s disease have also been associated with this presentation.

The increasing rates of gender affirming surgery have highlighted the high fistula rates after phalloplasty and metoidioplasty in these patients [8]. These are covered in further detail elsewhere in the book. Finally, infrequent causes of UCF include trauma, previous radiation, penile piercings, circumcision, and other self-inflicted insults.

20.2 Evaluation

Anterior urethral UCF are generally self-evident, with patients complaining of urine extrusion from an alternate orifice while voiding. In distal pendulous or fossa navicularis fistulae, patients may complain of split-stream, and in smaller bulbar fistulae, only mild wetness of the perineum may be observed by the patient. Since these fistu-

lae are distal to the external urinary sphincter, leakage is generally not continuous unless coexisting sphincter damage or a proximal pathology is also present.

The patient’s surgical history will be germane. A history of hypospadias repair, urethral dilations, urethroplasty and other surgeries should be elicited. Physical exam may give clues as to prior surgeries and may reveal the fistula itself. A combination of urethroscopy and urethrography will definitively establish the presence of fistula, its location, severity and any other anomalies. It is imperative to assess the entirety of the urethra focusing on any narrowing or stricturing distal to the fistula, health of the urethral mucosa, presence of hair in the urethra, masses, stones etc. In patients with an evident inflammatory process, adjunctive imaging with magnetic resonance imaging may be helpful to evaluate surrounding musculoskeletal or soft tissue involvement.

An assessment of the patient’s overall voiding symptoms should be made, as should the presence of hematuria, recurrent infections or other associated complaints that may necessitate abdominal imaging and bladder evaluation. It is essential to understand the patient’s goals of treatment before embarking on repair. A subset of patients will choose to observe a minimally symptomatic distal fistula, while others with complex fistulas may opt for a perineal urethrotomy or even urinary diversion as a definitive treatment [9].

20.3 Management

20.3.1 Early Postoperative Leak

Early postoperative extravasation following urethroplasty is due to incomplete healing of suture lines. Reported rates of extravasation vary from 1% to 64% and depend on the type of repair and timing of follow-up imaging [4]. In a prospective study of short segment (<2 cm) urethral strictures treated with excision and primary anastomosis (EPA), 18 out of 28 patients had contrast extravasation on pericatheter retrograde

urethrogram on post-operative day (POD) 14 while there was only 1 patient with a continued leak at POD 21, and zero leaks at POD 28 [10]. A larger study of 168 patients showed a 1% rate of extravasation at POD 14 for bulbar stricture EPA [11]. This urine leak is due to incomplete healing of the suture lines, and is not a mature fistula, as epithelized tracts have not formed. In the majority of cases, continued stenting and drainage across the repair will help resolve the situation. In our practice, a urethral catheter is left in for 10–14 days after an excision and primary anastomosis, and for 3 weeks after an augmented repair. If extravasation is present on postoperative urethrogram, the catheter is left in for another 1–2 weeks (Fig. 20.2). If urinary extravasation continues for 6 weeks or more after urethroplasty, it is unlikely to heal conservatively. At this time, the presence of a catheter across the fistula probably causes more harm than good due to foreign body irritation. The catheter is discontinued, and the fistula is allowed to declare itself before embarking on repair. After the fistula has stabilized, a combination of cystourethroscopy and urethrography should be performed to evaluate the area of the fistula and the remainder of the lower urinary tract (Fig. 20.3). An appropriate repair is then planned.

20.3.2 Non Operative Management

In a patient with a small, distal fistula, it is not unreasonable to eschew surgical repair. This is especially true in adult hypospadiacs who have had multiple prior repairs. These patients can generally occlude the fistulous tract with a finger while voiding to minimize spraying. Nevertheless, it is important to fully evaluate the rest of their urethra for strictures, diverticuli, presence of hair bearing skin – traits that would make one inclined to offer repair.

20.3.3 Surgical Repair

20.3.3.1 General Principles of Repair

The first decision point in planning a repair for a UCF is the caliber and health of the adjacent urethra. If the remainder of the urethra is acceptable in caliber and quality, a single stage fistula repair can be planned. In the event of a co-existing simple urethral stricture, concomitant urethroplasty and fistula repair may be done. A staged repair may be advisable in patients with multi-focality of strictures and/or poor urethral tissue in addition to the fistula (Please see algorithm – Fig. 20.4). Patch grafts are employed to augment the urethral defect. Split thickness skin

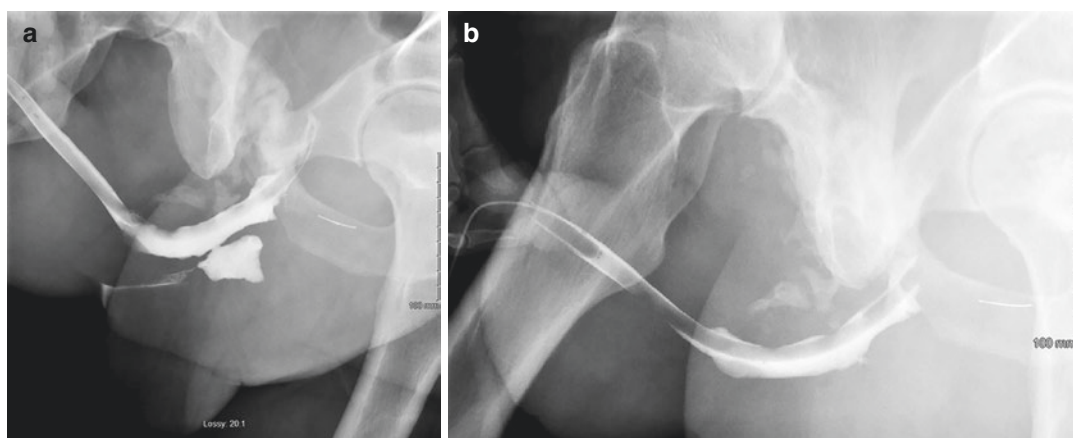


Fig. 20.2 Postoperative leak after a second stage urethroplasty. Patient with pelvic trauma, osteomyelitis, urinary infections and long segment urethral loss. He was treated with a two-stage repair with a Singapore flap for coverage.

Three weeks after the second stage, a peri-catheter retrograde urethrogram showed modest extravasation (a). The catheter was left in for 2 more weeks, and the extravasation resolved (b)

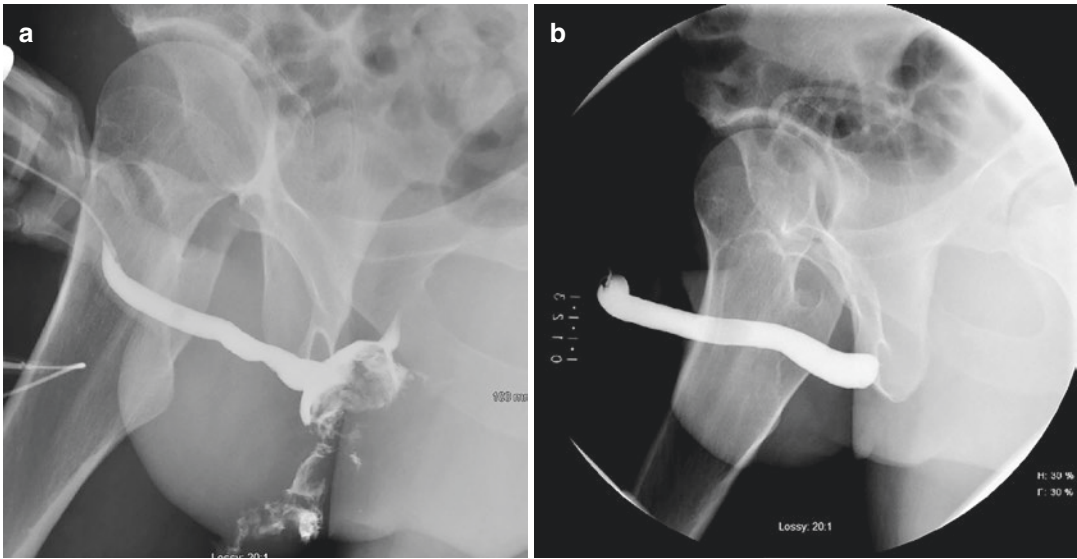


Fig. 20.3 Straddle injury and extravasation. A 25 year-old male with a straddle injury that was emergently explored at an outside facility. He had continued drainage of sero-uriferous fluid from his perineal wound. A retrograde urethrogram confirmed urethral disruption and

extravasation to the skin (a). A suprapubic catheter was placed and 6-week interval imaging showed resolution of extravasation and declaration of an obliterative stricture (b). He was treated with a straightforward excision and primary anastomosis

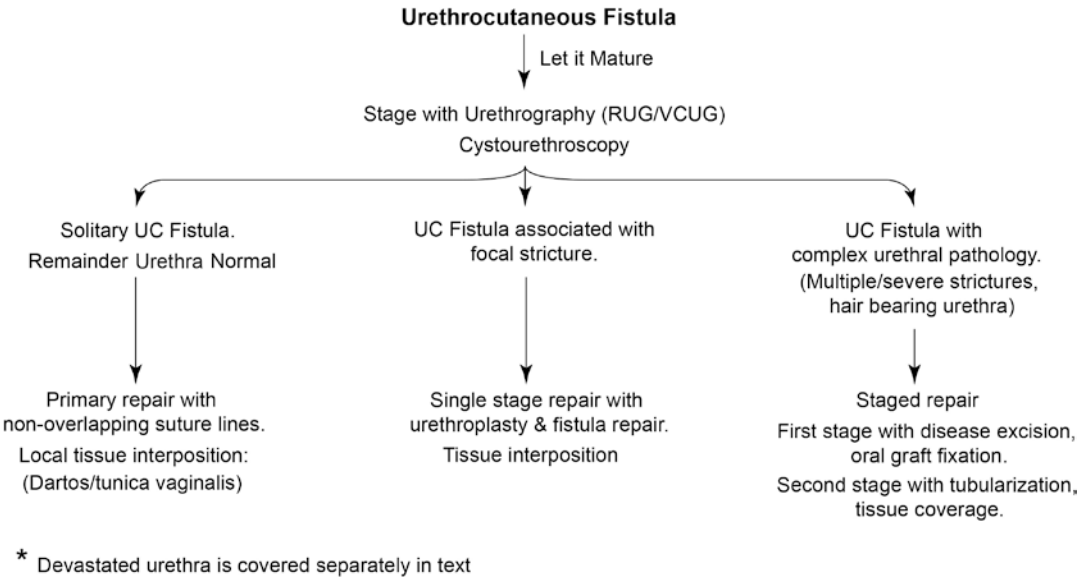


Fig. 20.4 Suggested algorithm for management of a urethrocutaneous fistula. Treatment strategies should take into

account the caliber of the adjacent urethra, health of the surrounding tissue, and be directed toward objective patient goals

grafts of penile skin have been largely replaced by buccal mucosa and occasionally lingual mucosa, which have shown superior long term success [12, 13].

In patients with devastated urethras desiring repair, a staged repair should be considered standard. Robust, healthy tissue from regional sources must be brought in to augment the repair e.g. the

gracilis myocutaneous flap, the perineal artery fasciocutaneous (Singapore) flap, the pedicled internal pudendal artery perforator (IPAP) flap, among others [12, 14]. The gracilis muscle is commonly used in perineal surgeries for its proximity, ease of harvest, and broad mobilization [15]. It can be used to cover buccal mucosal graft or just to improve regional vascularity, reduce dead space, and promote healing [16]. The Singapore flap was first used in vaginal reconstruction to provide sensate coverage. Although they do not have the immunologic qualities of muscle flaps, fasciocutaneous flaps are less bulky and easily harvested [17]. IPAP flaps refer to the multitude of tissue options that use the abundant perforating arteries in the perineum. They have been used as island flaps or pedicled coverage [14, 18].

20.3.3.2 Technical Considerations

Once in the operating room, the patient is placed in an appropriate position: supine for penile urethral reconstruction, lithotomy for all others. Intraoperative delineation of the fistula should

be done with a lacrimal duct probe, guidewire, urethral instillation of fluid (irrigation, viscous lidocaine, methylene blue), or a combination of the above. The fistula opening on the skin is circumferentially incised, and the fistula tract is excised down to the urethra. Multi-layered closure is done, and local tissue is mobilized to cover the urethra. Non-overlapping suture lines are preferred. A urethral catheter is left in for 3 weeks. In re-do cases, a suprapubic catheter may be added (Fig. 20.5). Minor technical modifications have been illustrated in the literature – mostly focusing on solitary UCF after hypospadias repair. The PATIO technique (preserve the tract and turn it inside out) is an elegant modification that involves inverting the fistula tract inside the lumen and closing the skin over it [19]. A tunneled tunica vaginalis flap avoids long suture lines and provides healthy tissue interposition [20].

UCF after penile piercings constitute a unique cohort. These fistulae are distal, right at the level of the coronal sulcus. These can be repaired by a glans cap approach, preserving the glans by

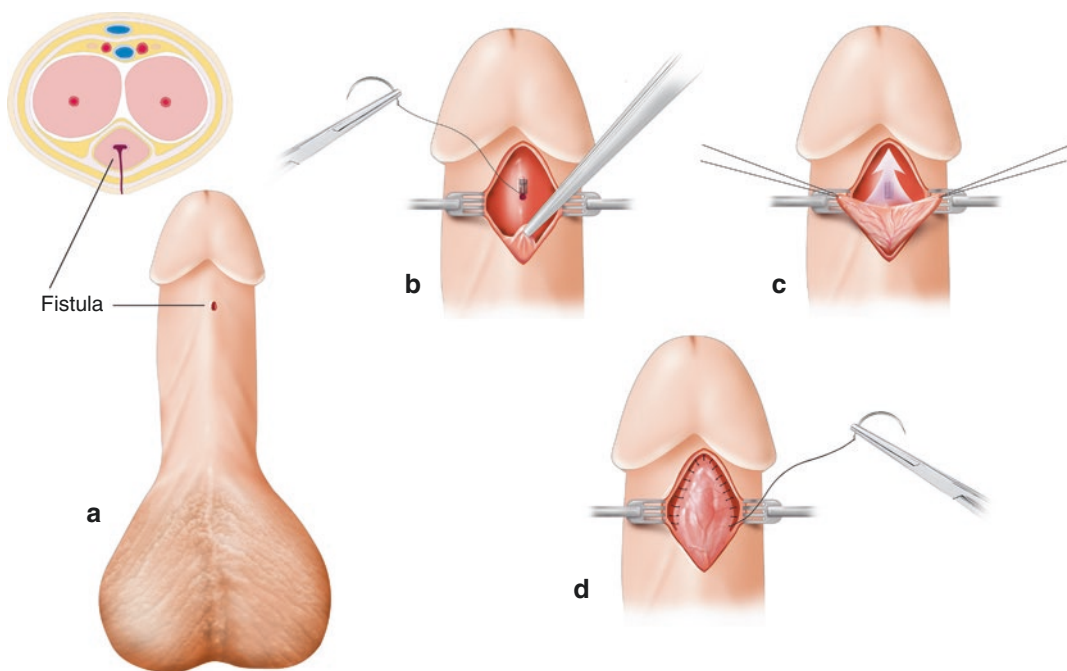


Fig. 20.5 Schematic for repair of simple urethrocutaneous fistula (a). Fistula is excised and closed in multiple layers (b and c) with non-overlapping suture line. Local tissue is mobilized for coverage (c and d)

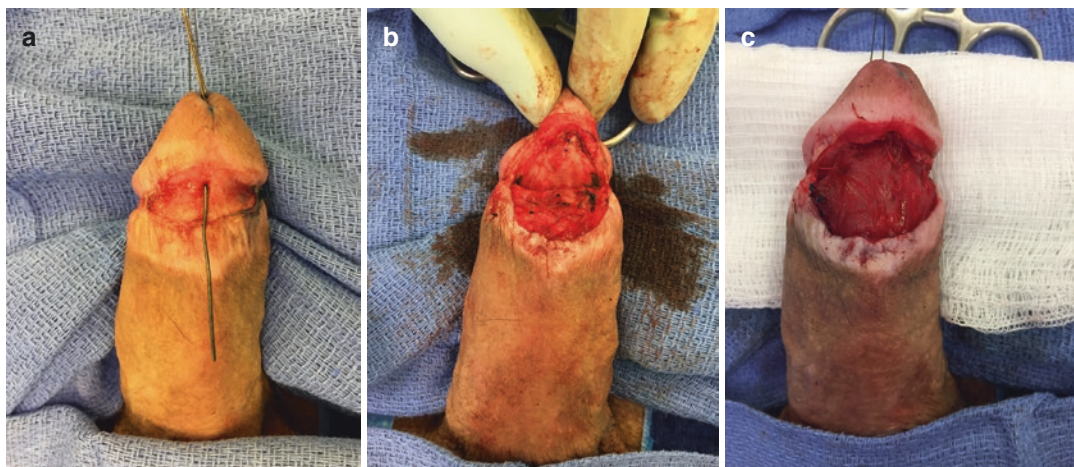


Fig. 20.6 Urethrocutaneous fistula after penile piercings. Most of these close spontaneously, but in a few cases, surgical intervention is needed. Common piercings associated with fistulae include *Prince Albert* and *Apadravya*. This patient had a persistent fistula after removal of an

Apadravya piercing. Fistula was located proximal to the coronal sulcus (**a**). A glans cap approach was used: the glans lifted up, the fistula repaired, and local dartos used to cover the repair (**b** and **c**)

avoiding glans wing division [21]. A transverse subcoronal incision is made, the glans cap is raised, and the fistula exposed and repaired. If there is a coexisting fossa stricture, this can be simultaneously repaired with an oral graft inlay. Local dartos tissue is mobilized for additional coverage, and the glans cap replaced on the urethra (Fig. 20.6). In patients with a UCF associated with a stricture (usually distal to the fistula), excision of the fistulous tract, urethroplasty (either excision and primary anastomosis or buccal augmented repair), and local coverage may be done in the same setting (Fig. 20.7).

20.3.3.3 Staged Repair

When planning a staged repair, it is important to consider the source of the urethral lumen and the source of the coverage tissue. In the most basic Johanson type staged repair, the worst of the diseased urethral segment is excised, and proximal and distal urethrostomies are matured. After a certain period of time has elapsed, the neo-urethra is tubularized after incorporating adjacent skin [22]. More commonly, however, a Bracka modification is made wherein healthy oral mucosal graft is affixed onto the underlying tunica of the cavernosal bodies between the proximal

and distal urethrostomies, thus forming the neo-urethral plate [23]. After 6 months, peri-urethral incisions are made, and the neo-urethra (made predominantly of the oral graft) is tubularized over a catheter. A 3 cm wide urethral plate is needed for tubularization into an adequate lumen, and often times graft contracture or inadequate width is an issue. This can be addressed by a deep dorsal incision and inlay of an additional oral graft during the second stage [24]. Thus the entire neo-urethra is made with oral graft. Another option is to construct the ventral plate of the urethra with a fasciocutaneous flap from non-hair bearing penile skin if this tissue is healthy and readily available. If there is sufficient penile shaft skin, a longitudinal skin island (Orandi) flap or a circular penile fasciocutaneous (McAninch) flap can be harvested to create the neourethra [25, 26]. They are hairless, well-vascularized, and can reach any part of the urethra, however, they require longer operative times [27], and can cause penile distortion or altered sensation [28]. Finally, coverage of the tubularized urethra with a well vascularized interposition tissue is mandated. A dartos flap is often not reliable in a re-do situation. A tunica vaginalis flap harvested through the same incision or

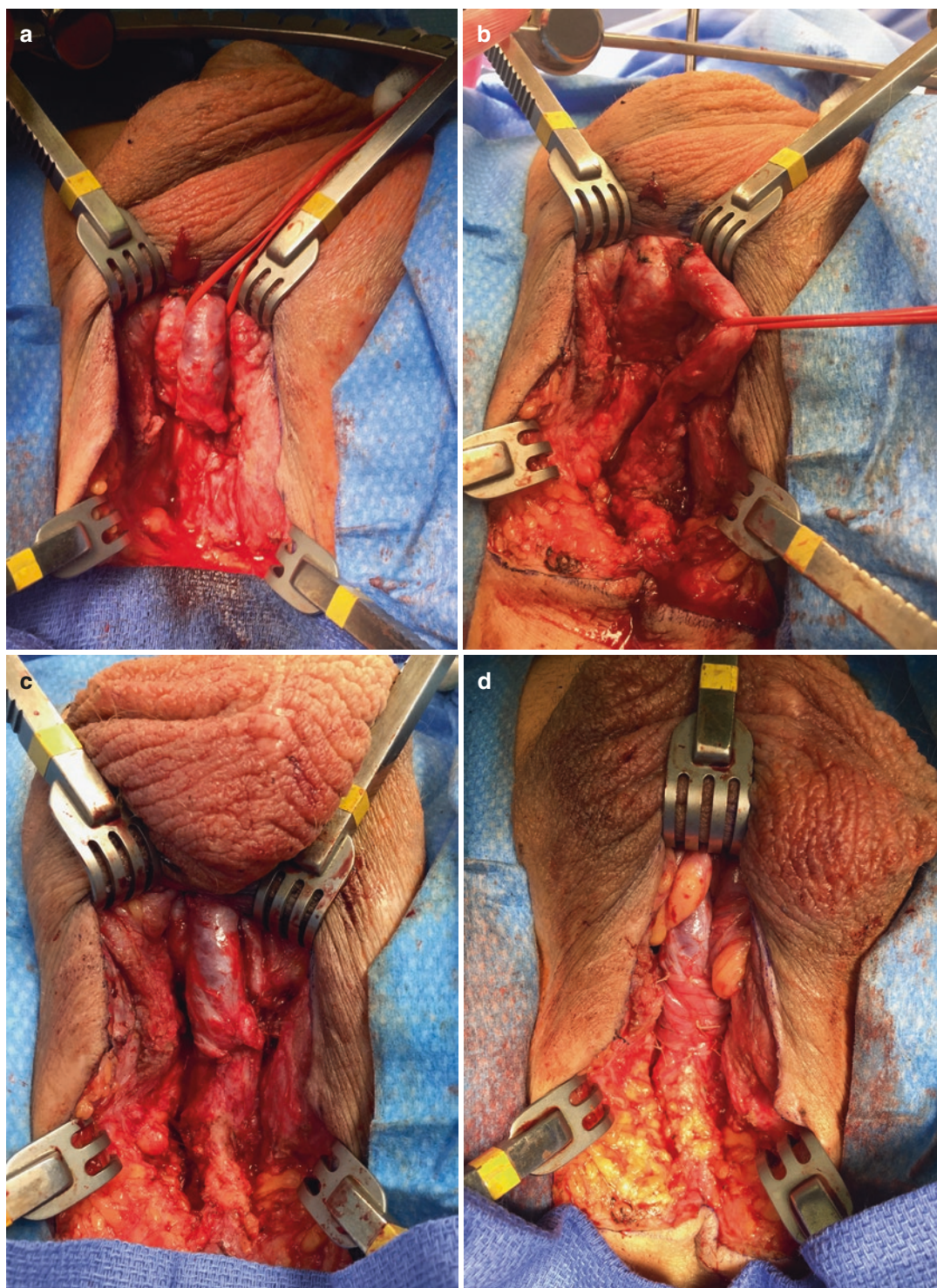


Fig. 20.7 Urethrocutaneous fistula associated with mesh erosion and stricture. Patient had a transobturator sling placed at an outside facility that was complicated by a urethral injury. After a period of urinary diversion and urethral rest, he healed with a stricture and a small proximal fistula. He underwent an exploration with removal of mesh, removal

of affected urethra and an anastomotic urethroplasty (a–c). Due to poor tissue quality secondary to erosion and prior radiation, a tunica vaginalis flap was used to cover the repair (d). If there is concern about the repair or the surrounding tissues are unhealthy, a more robust source of coverage such as the gracilis muscle should be considered

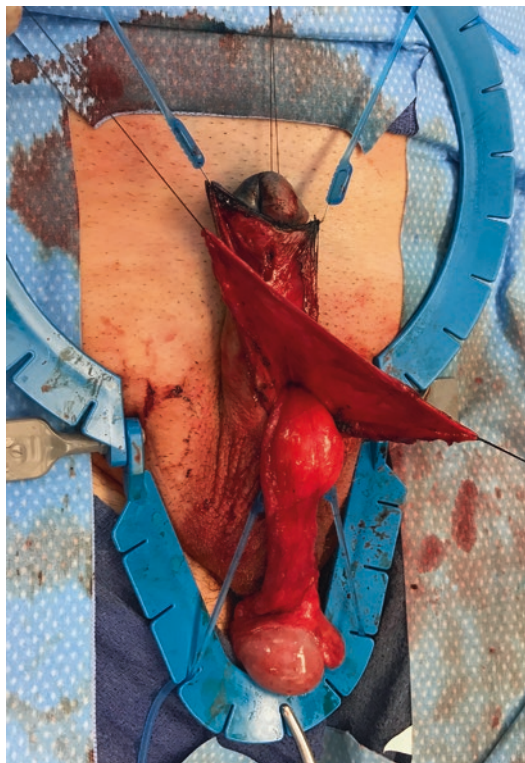


Fig. 20.8 Tunica vaginalis provides reliable coverage after urethroplasty as well as urethrocutaneous fistula repair. This can be harvested through the same incision or a small separate scrotal incision

a small separate scrotal incision can provide good quality tissue interposition (Fig. 20.8).

A special circumstance involves the devastated urethra with associated fistulation. This may be due to trauma, multiple prior surgeries, strictures associated with multiple infections, perineal abscesses, pubic osteomyelitis, regional necrotizing fasciitis or a combination of the above factors. A milieu of local sepsis and hypoxemia complicates the already devastating trifecta of urethral narrowing, UCF, and paucity of good quality local tissue. On occasion, surgical debridement with urinary diversion is the first step before planning any repair. In patients with an unclear etiology, tissue biopsy should be taken to rule out malignancy (Fig. 20.9). After the local inflammation has subsided with adequate exteriorization and drainage, an interval assessment with antegrade and retrograde ure-

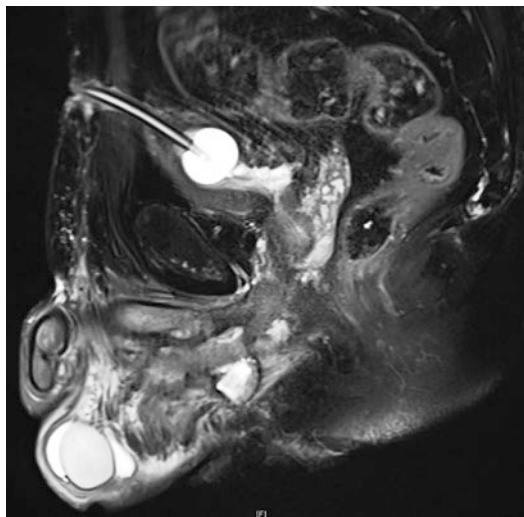


Fig. 20.9 MRI of a patient presenting with multiple urethro-perineal fistulae, and a palpable mass in the perineum. T2 sagittal images show soft tissue mass involving bilateral corpora cavernosa and extending to perineum. CT guided biopsy confirmed poorly differentiated squamous cell carcinoma. (Image courtesy John M. Lacy, MD)

thrography and endoscopy should be performed. Prior to proceeding with reconstruction, a candid conversation with the patient helps delineate the goals of treatment. While it is almost always possible to reconstruct the anterior urethra, the utility of reconstruction declines with multiple surgeries; and it is wise to discuss the option of urinary diversion with these patients. If reconstruction is planned, consideration should be given to the source of the urethral lumen, source of tissue coverage, and the source of skin coverage. A two-stage approach is preferred [29]. In the first stage, the dorsal aspect of the urethral plate is formed with an oral graft. If the underlying cavernosal bodies do not provide a good bed for graft take, a muscle flap or a de-epithelized fasciocutaneous flap is used to provide a bed for the oral graft. After a period of time has elapsed (generally 3–6 months), the ventral aspect of the urethra is constructed. A tubularization of the previously placed oral graft may be attempted, but it is often difficult due to lack of underlying supporting tissue. Therefore, a second oral mucosal graft is often required for the ventral

aspect of the urethra and covered by a well-vascularized flap. The gracilis muscle works well in this setting as this provides support for the graft, and works as an excellent soft tissue filler. Alternatively, a de-epithelialized fasciocutaneous flap based on an internal pudendal perforator is used. In cases with deficient perineal skin, local tissue rearrangement with Y-V advancement, transposition, or lotus petal flaps can be performed [30]. An alternative to two-staged reconstruction of a devastated urethra is enterourethroplasty – a technique discussed elsewhere in the book.

20.4 Summary

Urethrocuteaneous fistulae often present in previously operated on and compromised tissues. Repair options are dictated by evaluation of patient goals, fistula location, co-existing abnormalities, and health of urethral and surrounding tissues. The reconstructive urologist should be familiar with an array of repair options and be ready to adapt as needed to the situation.

Key Summary Points

- Common causes of urethrocuteaneous fistulae include prior hypospadias and stricture surgery, infection, and trauma.
- Diagnosis is established with physical examination, urethrography, and endoscopy.
- Staging involves determining the location and multiplicity of fistulae, and the health of the surrounding tissue including the caliber of the remainder of the urethra.
- Simple fistulae can be repaired in a single stage while complex fistulae require a two or multi-staged approach employing advanced reconstructive techniques.
- A goal directed, algorithmic approach may help simplify decision making in a patient centered fashion.

Acknowledgments Tom Dolan, MS, prepared the figures and illustrations

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Surgical Reconstruction of Pelvic Fracture Urethral Injury

21

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21.1 Introduction

Posterior Urethral injuries after Pelvic Fracture are one of the most devastating and debilitating situations in Urology. It represents a real surgical and decision-making challenge. The adequate initial and late management to this problem with a multidisciplinary approach could avoid many possible urosexual and orthopedic complications, offering the best results to these patients.

21.2 Indicence

The incidence of Posterior urethral injury varied from 3% to 25% average 9.9% of Pelvic Fractures [1, 2]. The mean age of presentation is 33-year-men in the majority of series reported [3–5]. Other causes less common are described like gunshot injuries and explosive blasts [6], Female urethral injuries due to pelvic fracture are very rare 0.7% reported in large series [7].

21.3 Etiology

Different Mechanism of urethral injury have been proposed, these include Crush, laceration, avulsion and distraction. In some severe cases the bladder, bladder neck, rectum could be damage too. The pubic ramus and ischium can act as “switch-blade” and lacerate or disrupt the urethra, other explanations propose a shearing force which leads to disruption of the membranous urethra from the apex of the prostate [8].

At present, we know that these injuries occur distal to the striated sphincter in the majority of cases (70–75%) [9, 10] demonstrated urodynamically [11] cystoscopically [10], and surgically [12].

The etiology, severity and management of posterior urethral injury is related according to demographic location. In developed countries, the most common etiology is motor vehicle accidents. Morey et al. reported 40% associated car to pedestrian, car to motorcycle 26% and falling down and crash injuries in 26% [13].

In developing countries pedestrian (35%), motorcycle (26.5%), bicycle (12.8%) accidents are more common. Nevertheless, the severity and complexity of these injuries increases in the developing countries and seems to be related to the initial management. In developing countries, the primary treatment is given by general surgeon in comparison with developed countries that are given by a urologist [5]. Other causes less common are described like gunshot injuries and explosive blasts [6].

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21.4 Mechanism of Injury

The true anatomical pelvis is composed by the pubic arch and symphysis pubis in the anterior part, the iliac bones lateral, the sacrum and the sacroiliac joints in the posterior. Pelvic fractures may be classified in stable or unstable [14].

Pelvic fractures may also be classified according to the direction of the force injury. The major forces are anteroposterior compression, lateral compression with or without rotation and vertical shear. Anteroposterior and lateral compression fractures may be associated with stable or unstable hemipelvis but vertical shear fractures are grossly unstable [15].

The puboprostatic ligaments and the perineal membrane are critical in the injury mechanism of the lower urinary tract, as they share an attachment with both, the anterior pelvic ring might therefore apply traction to the urethra. There are four attachments, as either the right or left hemipelvis and in some cases both sides are displaced. The pattern of ligament damage depends of the direction and velocity of the trauma forces. Recently we know that the majority of injuries occur at the junction of the membranous urethra and the bulbar urethra, leaving the urethral sphincter mechanism intact.

There are three types of urethral injury: contusions, partial ruptures and complete ruptures.

An injury that has incompletely ruptured part of the circumference of the urethra is a contusion, in this cases healing is possible without stricture formation. An injury that has completely ruptured part of the circumference of the urethra is a partial injury. And a complete rupture is when the injury has completely rupture the entire circumference of the urethra. In these cases, the stricture formation is inevitable.

Each mechanism of urethral injury is associated to different types of pelvic fracture. There are various classifications of pelvic fracture the most widely used is the Tile Classification (Table 21.1) [16].

21.5 Initial Management

The initial management is focused in stabilization of the patient based in the trauma protocols. A multidisciplinary approach must be done. Once the patient is stable we can make immediate management of PFUDD with endoscopic realignment (early or delayed) or cystostomy with delayed repair. Each approach must be evaluated carefully depending the patient condition, mechanism, severity of trauma and kind of urethral damage.

The aim of early realignment is to better align the proximal urethra and the distal stump to minimize stricture or defect. The recent progress of

Table 21.1 The Tile classification of PRFs

Type	Detail	Urethral injury mechanism	
A	Stable pelvic ring fracture	Unilateral.	Bilateral
	A1 fracture not involving pelvic ring		
	A2 un displaced pelvic ring fracture		
	A3 transverse sacro-coccygeal fracture		
B	Rotationally unstable, vertically stable		
	B1 open book antero-posterior compression.		(bladder neck, anorectal injury, Sacral plexus, perineo-genital degloving, disruption of pelvic floor.) (Disruption / Distraction)
	B2 lateral compression fracture		
	B2.1 ipsilateral compression fracture (including tilt fracture)		
	B2.2 contralateral compression fracture (windswept pelvis)		
C	Rotationally unstable, vertically unstable		
	C1.1 unilateral iliac crest fracture		
	C1.2 unilateral sacroiliac-joint fracture dislocation (crescent fracture)		
	C1.3 +Sacral fracture unilateral sacroiliac-joint fracture dislocation		
	C2 bilateral (one side Type B, one side Type C)		
	C3 bilateral Type C		

endourological techniques make more feasible a successful alienation. Several studies justified this approach because it could give a chance to the patients to avoid a future surgery and if this failed, the surgery becomes more easy and surgical approach less aggressive. The disadvantage of this approach is the association with erectile dysfunction and incontinence. Other complication has been reported as false passages, bladder neck injury, infection, cavities, anterior urethral damage and others. This support that initial cystostomy with delayed repair is safer, less blood loss, simple approach and lower the resulting rates of impotence and incontinence [17].

Other associated injuries may be present in these patients that requires immediate surgical open repair. Intraperitoneal bladder rupture, rectal injuries (rarely reported 3%) and bladder neck and prostate injuries. Rectal injury is frequently associated with concurrent bladder neck lacerations [18]. Bladder neck injuries are more common in children cause is more vulnerable, in adults the typical injury occur in the midline of both the bladder neck and prostatic urethra in association with lateral compression fracture of the pelvis or an open – book injury [19].

This condition must be repaired immediately trying to restore an acceptable degree of continence. Other rare associated injuries have been described like sequestered prostate and blow out of the prostate [20].

21.6 Clinical Findings

Clinical diagnosis of urethral injury in PFUDD must be suspected by history and nature of trauma. Patient with vehicle accident, pedestrian accident, motor vehicle accident or fall from height with inability to void, blood in the urethral meatus, perineal hematoma (butterfly shape). Physical examination may reveal malrotation of the hemi pelvis and compression of the iliac crest will indicate pelvic instability. Shortening of the extremity could be secondary to displaced pelvic ring. Abdominal examination is important to identify full bladder cause urine retention but and hematoma or intraperitoneal bleeding could

mask a full bladder. Inspection of the anus is mandatory, elevated prostate is difficult to palpate in young patients so the main goal of digital examination is to exclude rectal injury. The absence of these signs does not exclude the presence of urethral injury.

So, the urethrogram is the cornerstone of diagnosis in these situations [21].

21.7 Preoperative Evaluation

21.7.1 Imaging

Actually, the most widespread and gold standard image diagnostic method for PFUDD is the combined dynamic retrograde urethrography (RUG) and voiding cystourethrography (VCUG), these assess the continuity of urethra, site, severity and length of urethral injuries, bladder neck competence (open or closed) state of the bladder (Capacity, ureteral reflux, stones, diverticulum, fistula). This study could be done when we suspected clinically urethral injury in the acute phase of pelvic trauma and the patient is stable. But is usually done within a week of injury or if we are planning a delayed primary repair is done after 3 months.

Colapinto and McCallum classified posterior urethral injuries in three types [22]

- *Type 1.* The prostate or the urogenital diaphragm is dislocated, causing elongation and tension of the bulbomembranous urethra. There may be urethral contusion or laceration.
- *Type 2.* The membranous urethra is ruptured above the urogenital diaphragm, with or without prostatic injury. The bulbar urethra is intact. The rupture must be partial or complete.
- *Type 3.* The membranous urethra is disrupted above and below the urogenital diaphragm. The rupture usually is complete and may be associated with rupture of the urogenital diaphragm and or rupture of the bulbar urethra.

Recently Goldman et al. proposed a new anatomically based classification to compare the

treatment options and outcomes of each kind of injury [23].

21.7.1.1 Goldman Classification

- I Posterior urethra stretched but intact.
- II Tear of the prostatomembranous urethra above the urogenital diaphragm.
- III Partial or complete tear of both anterior and posterior urethra with disruption of the urogenital diaphragm.
- IV Bladder injury extending into the urethra, Iva Injury of the Bladder base with periurethral extravasation simulating posterior urethral injury.
- V Partial or complete pure anterior urethral injury.

Koraitim proposed that the surgical approach needed not only depends on the urethral defect. But also on the length of bulbar urethra, so he proposed the urethrometry index or gapometry which is calculated by dividing the length of the urethral defect by the length of the bulbar urethra (from the proximal urethra to the penoscrotal junction) Fig. () an index <0.35 predicted simple perineal approach and index >0.35 predicted progressive perineal maneuvers [24]. The disadvantage is that this index could be modified if the X ray is not correctly done [25].

21.8 Technique

A plain X-Ray is done at the beginning to evaluate healing fracture of the pelvis, an exclude possible stones in the bladder. The RUG and downogram must be performed by the treating urologist using fluoroscopy. This is a dynamic study so we can evaluate urethral distensibility, bladder capacity, bladder neck function and other situations.

We suggest start with alfa blockers 2 days before the study for promote bladder neck opening for better evaluation of the posterior urethra. we start by filling the bladder through the suprapubic tube with contrast added to 500 cc of saline solution, the instillation must be slow until the bladder is full. Then the genital area is prepared

with povidone iodine. The patient is placed in an oblique position and contrast injected gently through the urethra. This will show us the gap between proximal and distal ends of the urethra (Fig).

Sometimes the bladder neck does not open even alfa blockers are administrated before. In this situation, we can combine fluoroscopic evaluation with RUG plus.

Flexible antegrade scope from suprapubic tract. This is very useful cause we can evaluate under vision adequate bladder neck integrity, prostatic urethra and if the injury involves the membranous urethra or the mechanism of the distal sphincter is preserved [26] the fluoroscopy plus flexible scope give us too accurate evaluation of the proximal gap (Fig).

The adequate image assessment of the PFUDD can predict which surgical approach will be required [27].

21.9 Penile Doppler Ultrasound

Erectile dysfunction is a common sequel of pelvic fracture particularly those associated with posterior urethral injury when it can be neurogenic or arteriogenic due to damage of the cavernous nerves or branches of the pudendal arteries. The incidence of ED in PFUDD patients range between (27.5–73%) [28].

Penile Duplex Doppler ultrasound had documented in patients with PFUDD that 48.7% of this had arterial ED, 14.6% Venous Leak and 36.5% had non-vascular ED most likely to neurogenic etiology [29].

A multivariate analysis documented that diastasis of the pubic symphysis, lateral prostatic displacement, and a long urethral gap at surgery are predictors of ED [30].

Doppler duplex penile ultrasound with intracavernous injection (0.1 ml Trimix) are suggested in all patients with PFUDD. Systolic velocity < 25 ml/seg, rise time > 80 mseg or both suggest arteriogenic ED. Jordan G et al. reported high risk of ischemic bulbar necrosis after urethral reconstruction in these patients so they suggest primary penile revascularization previous to

definitive urethroplasty improving the quality of erections and outcomes in urethroplasty [31].

21.10 CT Scan

Patient with acute trauma is initially resuscitated in the ER, as part of the initial evaluation the CT scan one of the most used diagnostic methods. That means that in patients with PFUDD CT is made before any urethral evaluation. Currently Tomography is not used commonly for this situation but some CT findings can give us information about the injury of posterior urethra. These findings include obscuration of the urogenital diaphragmatic fat plane, hematoma of the ischio-cavernosus and obturator internus muscles and the prostatic contour, and obscuration of the bulbocavernosus muscle [32].

21.11 Magnetic Resonance Imaging

MRI is not the first option to evaluate patients with PFUDD but it could be used in complex injuries and REDO cases. This could provide useful information for planning the correct surgical approach in these patients. It correctly estimates the length of the gap, prostatic displacement, delineates the site and density of the scar tissue, reveals the presence of false passages and other associated injuries to repair. Recently has Joshi has proposed new protocol of MRI techniques that result much clear and useful for surgery planning [33]. Based on the same principle Joshi and Kulkarni now make 3 D Printed models of PFUDD which was presented at AUA meeting.

21.12 Operative Steps

21.12.1 Position and Preparation

Simple lithotomy position is needed, this is enough to give us an adequate exposure. Some surgeons prefer exaggerated lithotomy, but the risk neurovascular complications increase. The

patient should have antithrombotic stockings and intermittent pneumatic compression leggings. Allen yellowfin stirrups are the best for any kind of perineal surgery.

The skin is prepared with Chlorhexidine or betadine solution from the umbilicus down to the mid thigh and the patient draped to expose the perineum and the suprapubic area around any suprapubic catheter site or in case Access to the suprapubic area is required if abdominoperineal approach is needed in more complex patients. Prophylactic antibiotics are given intravenously with anesthesia or some days before if the preoperative cultures are positive.

21.12.2 Surgical Approach

A midline perineal incision (Fig. 21.1), is made along the line of the raphe. The incision is deepened through the subcutaneous tissue, Colles' fascia until the bulbospongiosus muscle in the center of the wound, exposing the urethra. (Fig. 21.2) The bulbospongiosus muscle is then carefully cut in its midline and detached laterally from the bulbar urethra. (Fig. 21.3) This frees the ventral aspect of the urethra back to the perineal body.

The proximal bulbar urethra is then separated posteriorly from the perineal body by sharp dissection, until we reach the membranous urethra it is then separated dorsally from the tunica albuginea of the corpora by dividing Bucks' fascia on either side of the urethra.



Fig. 21.1 Midline perineal incision

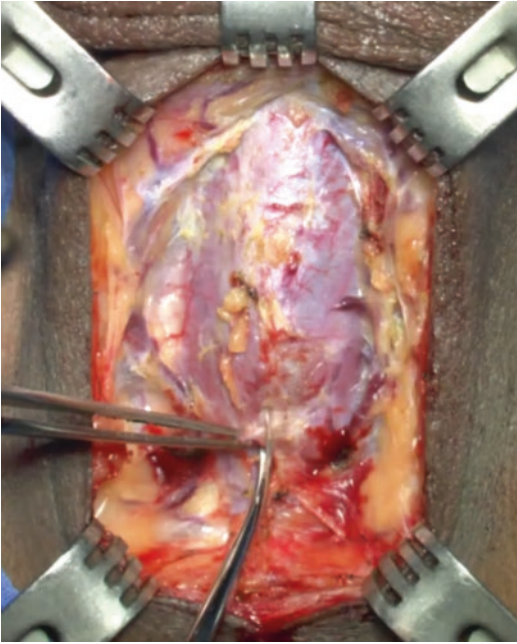


Fig. 21.2 Exposure of the bulbar urethra

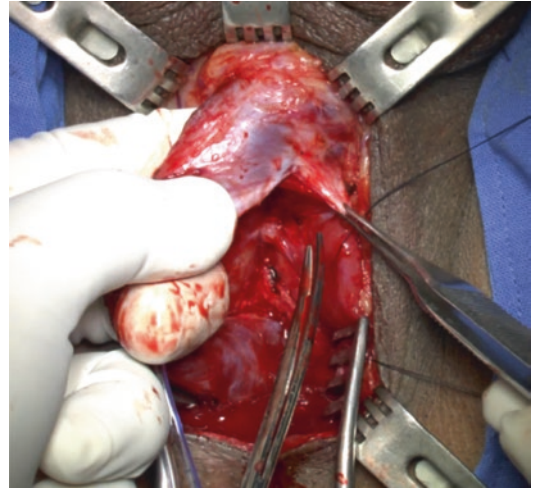


Fig. 21.4 Mobilization of the urethra proximal and distally

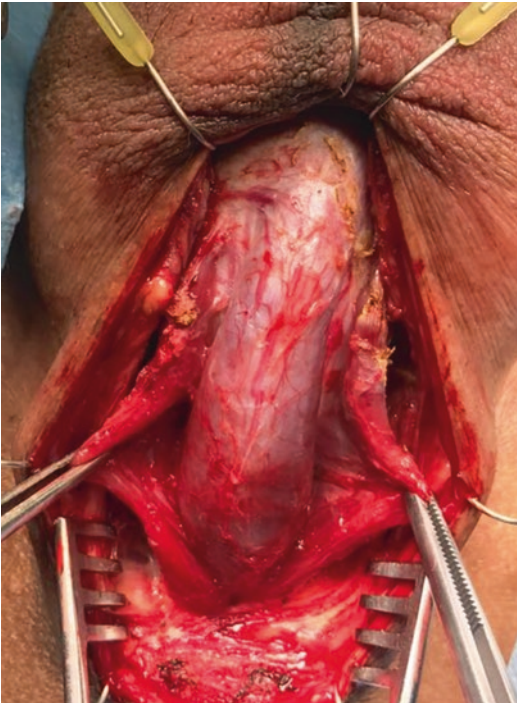


Fig. 21.3 Detaching of the bulbospongiosum muscle



Fig. 21.5 Mobilization until penoscrotal junction

(Fig. 21.4) The bulbar urethra should now be completely free distally until the peno-bulbar junction (Fig. 21.5). The remaining postero-lateral attachments are the points where the bulbar arteries run into the corpus spongiosum on

either side. In cases of pelvic fracture urethral injuries, the bulbourethral arteries are transected.

18 fr blunt tip catheter or metal sound is then passed carefully down the urethra to the site of the obstruction. The urethra is then transected through the site of obliteration (Fig. 21.6). The scarred tissue is removed until healthy mucosa is seen (Fig. 21.7).

Bulbar artery bleeding can be controlled by compression with gauze (Fig. 21.8). Then we can see with clarity the bulbar arteries and we can be

ligated, fulgurated with cautery or bipolar forceps (Fig. 21.9).

The next step is the most critical in the surgery. Find and reach the proximal gap of the urethra, in this step we have to remove all the scarred tissue that usually is dense, sharp cutting of the fibrosis is made with strong scissors or scalpel. Most patients will have a suprapubic catheter and through the suprapubic catheter tract a metal sound can be passed down into the bladder, and then into the prostatic urethra so that the tip of the metal sound can be felt through the fibrosis. It is then possible to cut down onto the tip of the sound (Fig. 21.10).

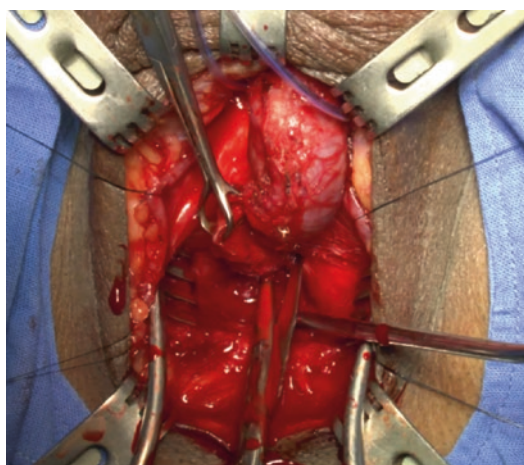


Fig. 21.6 Transection of the urethra in the scarred proximal urethra

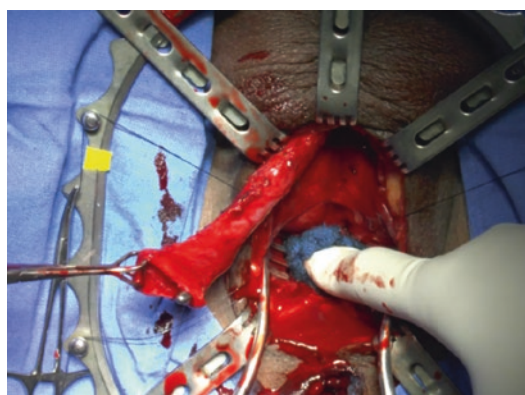


Fig. 21.8 Compression for bleeding control



Fig. 21.7 Retrograde bleeding after bulbar urethral transection

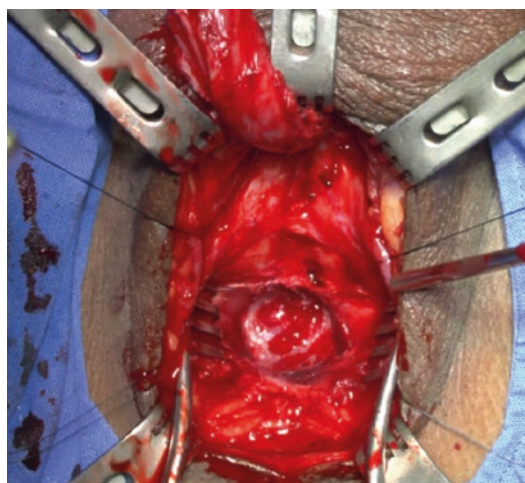


Fig. 21.9 Control of the bleeding

This is a blind maneuver so if the surgeon is not so experienced false passages through the bladder neck or posterior wall of the prostate can occur. An easy step is to pass a index finger in the rectum and feel the tip of the bougie in the rectum. Invariably the tip of the bougie will be at bulbo membranous junction. We can then cut in the direction of the palpated bougie. This needs a 3 dimensional visualisation. This step also avoids rectal injury. We insert finger in rectum and then dissect urethra in all patients with redo urethroplasty for PFUDD (Fig. 21.11). Another option is the Hosseini technique. flexible anterograde scoping is a very useful tool during intraoperative

localization of the proximal gap. The scope is passed through the bladder neck and the tip of the cystoscope is placed on the obliterated part of the proximal urethra. Then a needle is passed through the fibrotic tissue of the perineum until reach the proximal healthy urethra under direct endoscopic vision. A guidewire can be passed through the needle (Fig. 21.12). the scar tissue is cut until we find the healthy proximal urethra, this technique has two main advantages, we can avoid false passages and helps in determining the abnormal

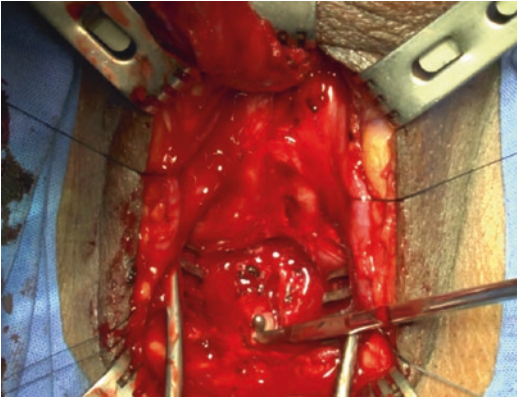


Fig. 21.10 Cutting in the tip of the metal sound



Fig. 21.12 Hosseini technique

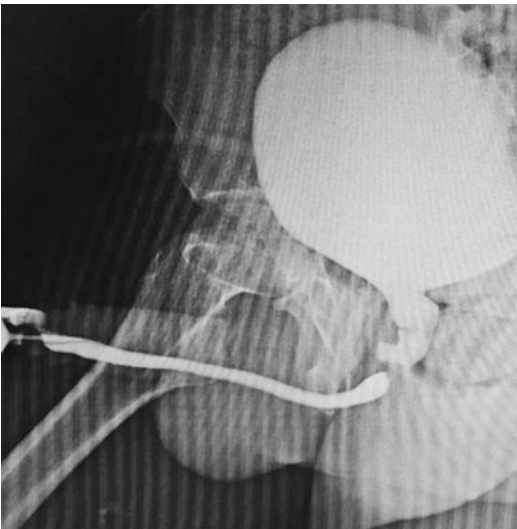


Fig. 21.11 Failed anastomosis through a false passage

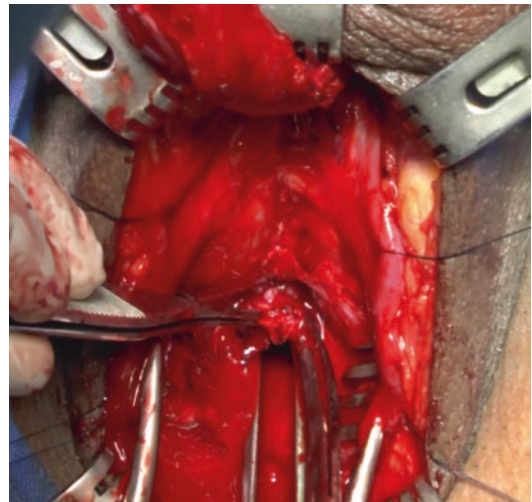


Fig. 21.13 Wide scarred tissue removal

placement of the proximal end of the urethra and its deviation on the rectum, lateral displacements and “S” shape deformity behind the pubis [34].

The margins of the proximal urethra are then exposed by trimming as much fibrotic tissue as necessary from around them (Fig. 21.13), without risking damage to the penile neurovascular structures by excessive dissection. Posterior urethra should be pink, supple and movable (Fig. 21.14).

The distal urethra now is spatulated 1 cm or 1.5 cm dorsally (Fig. 21.15). We do not recommend spatulating posterior urethra as usually this is the bulbomembranous junction.

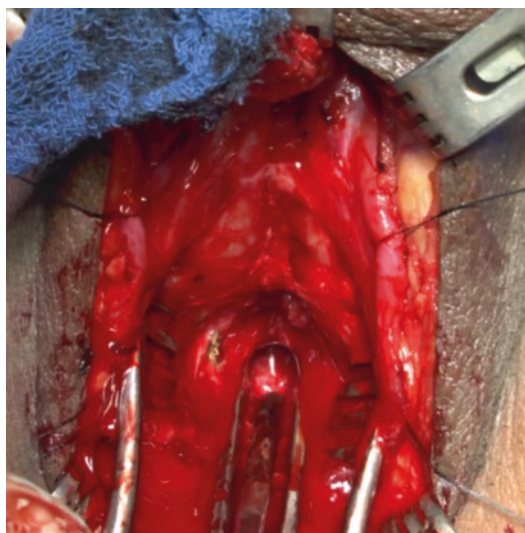


Fig. 21.14 Appearance of proximal healthy urethra

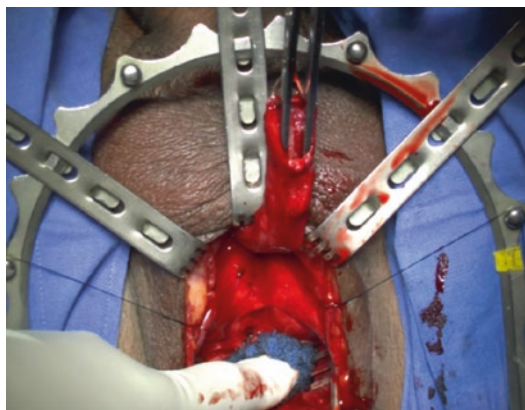


Fig. 21.15 Spatulated urethra

In an uncomplicated situation, where it is clearly possible to bring the two ends of the bulbar urethra together with no tension, nothing need be done other than to make a spatulated anastomosis. Six 4/0 Vycril or polyglactin sutures are placed around the circumference of the proximal gap.

Each suture collects the full thickness of the dorsal aspect of the distal urethra, 1 o'clock proximal (P) suture with 5 o'clock of distal (D) urethra. 11 (P): 7 (D) o'clock, 3 (P): 3 (D) o'clock, 9 (P): 9 (D) o'clock, 5 (P): 1 (D), and 7 (P) to 11 (D) o'clock. Then a 14 Fr or 16 Fr silicone Foley urethral catheter is passed up into the bladder and the sutures are tied in the parachute style (Fig. 21.16).

In more complicated cases where there has been a more significant loss of length, there may be tension in the anastomosis. There are two ways of resolving this. The first is to reduce some of the curvature of the bulbar urethra reducing tension on the anastomosis. This can be achieved by separating the two crura. There is a potential space 5–7 cm between two corpora in its proximal part. The ventral midline between the corpora is carefully incised to open the plane between them. We prefer using sharp dissection with knife or scissors (Fig. 21.17). Sometimes

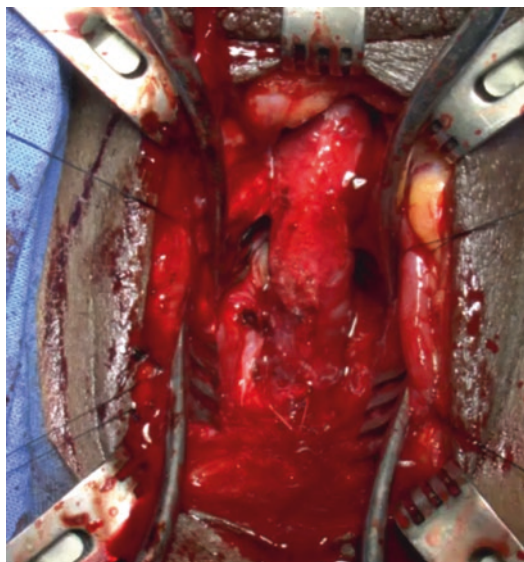


Fig. 21.16 Parachute style final anastomosis

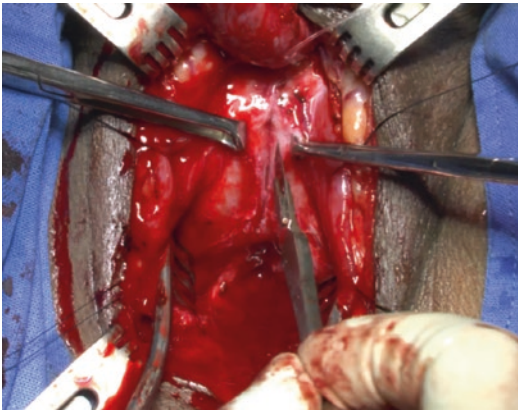


Fig. 21.17 Crural separation

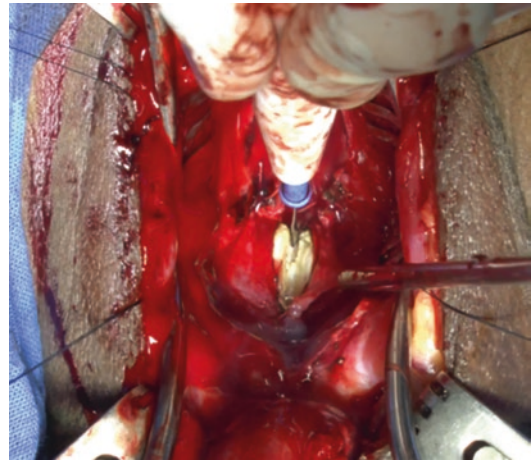


Fig. 21.19 Diathermy midline incision of the periosteum

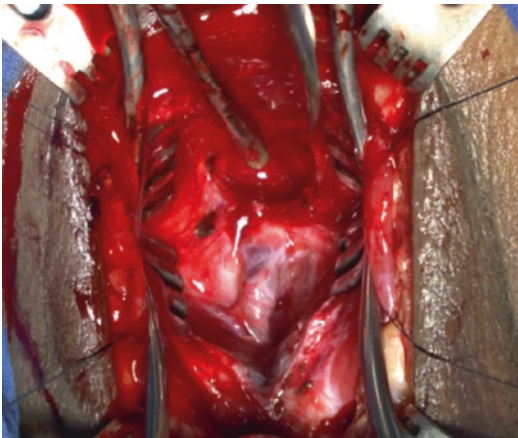


Fig. 21.18 Deep dorsal vein of the penis (arrow) during crural separation

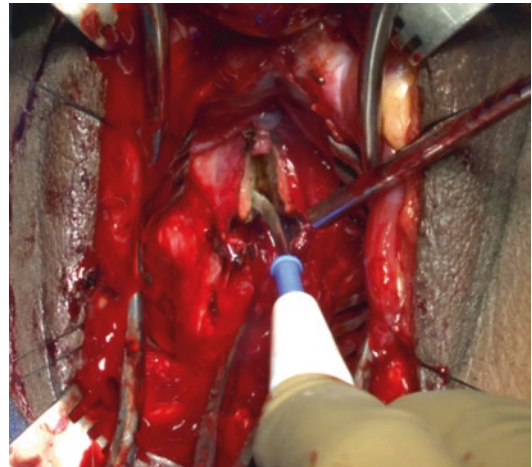


Fig. 21.20 Lateral detachment of the periosteum

it's difficult to find this virtual plane, during this step we can open the albuginea accidentally resulting in bleeding. Immediate repair with absorbable suture must be made. During crural separation its important to identify the deep dorsal vein of the penis (Fig. 21.18), cause its incidental damage could bleed a lot. This vein can be ligated or separated from the midline to preserved it. At the end of this maneuver the urethra can lie within the inter-crural plane and tension on the anastomosis is relieved.

In some complex cases, there will still be tension of the anastomosis produced by the pubic symphysis along the path between the peno-

bulbar junction and the apex of the prostate. At this step wedge pubectomy must be done as part of progressive perineal approach.

Once we identify the inferior arch of the pubis diathermy is used to incise in the midline the periosteum (Fig. 21.19) the tip of the cautery is blended 45 ° and detached the periosteum laterally (Fig. 21.20). Lateral to the deep dorsal vein are the dorsal arteries. By perisoteal elevation the arteires are safe gaurded from injury. Inital pubectomy is verticasl. If the posterior urethra is deep then horizontal and deep pubectomy may be needed. Joshi et al. have published a protcol of

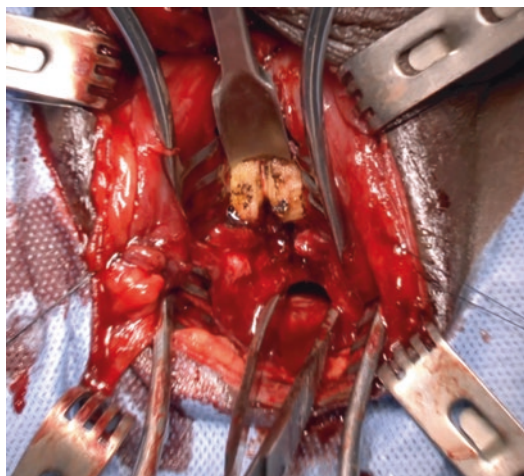


Fig. 21.21 Inferior pubectomy

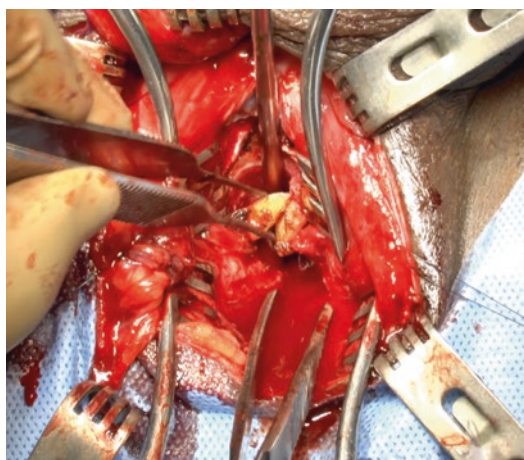


Fig. 21.22 Inferior pubectomy

MRI and also perform 3 D printing, which help in predicting the need for inferior pubectomy (Figs. 21.21 and 21.22).

Inferior pubectomy is required in more than 60% of our patients.

21.12.3 Supracrural Rerouting

Sometimes it's not possible to achieve a tension-free anastomosis even making wide inferior pubectomy. So, the surgeon must re-route the urethra around the crus at the peno-bulbar junction to straighten the natural curve of the bulbar

urethra completely. This maneuver could reduce 1.5–2 cm the length between the two ends of the urethra.

Having mobilized the bulbar urethra as far forward (Peno-bulbar junction), the anterior aspect of the pubis is exposed just to one side of the pubic symphysis (the left side for a right-handed surgeon or vice versa) by retracing the penis to the other side. The crus of the penis can then be detached from the pubic periosteum by carefully dividing its fascial attachment to expose the inferior pubic ramus.

Diathermy is used in the pubic periosteum and extend the pubectomy to make a wide channel through the bone for avoid compression of the urethra by the dorsal aspect of the crura that can results in bulbar ischemia.

The urethra can now be passed through the bony channel for an anastomosis made with six4/0 Vycril or polyglactin sutures placed and tied in the usual parachute style. At the end of the procedure, a 14 or 16 Fr silicone Foley urethral catheter is placed. Regular suture of the perineum by planes is made. The use of biologic hemostatic or drain can be used depending the surgeon choices. Finally, compressive perineal bandage dressings is placed and the patient is discharged 48 hr after surgery.

21.12.4 Abdominoperineal Reconstruction

The abdominoperineal approach is made when all the perineal progressive maneuvers are not enough to achieve a tension free anastomosis. Is reserved too when complication features exist like abscess, fistula or prior rectal injuries, bladder neck injury, pediatric cases with the classical “pie in the sky” bladder with extensive fibrosis, redo complex urethroplasty, double block at bulbomembranous junction and bladder neck – prostate injury.

Through a midline infraumbilical incision, the retropubic space and anterior part of the bladder is dissected. The periosteum over the anterior surface of the pubic bone is incised and posterior pubectomy performed. This avoids the

complications of total pubectomy such as waddling gait and hernias. We do not need to open the bladder. A retrograde boogie is passed through the bladder neck in to the prostatic urethra. The scar at the prostatic apex is excised. Six interrupted sutures are placed in positions 1,3,5,7,9 and 11 o clock using 4-0 polyglactin suture on a 16 mm 3/8 circle taper cut needle. A 14 fr Foley silicon catheter is placed across and the knots are tied after approximating the two urethral ends. at this point an omental gap is very useful for fills the dead space and keeps the anastomosis supple. The omentum is mobilized through a peritoneal window and placed around the anastomosis and fixed to itself with absorbable sutures. Abdominal and perineal drains could be used according to the surgeon criteria.

21.13 Conclusions

1. SPC and delayed urethroplasty is the standard of care in PFUDD. 2 Tensionfree anastomotic urethroplasty can be achieved with simple or progressive perineal approach. 3 Most challenging step in PFUDD is finding the posterior urethra. 4. Posterior Urethroplasty should be performed by experienced surgeons.

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Management of Urethral Injuries Associated with Complex Pelvic Fracture

22

Pankaj M. Joshi and Sanjay B. Kulkarni

22.1 Introduction

Pelvic fracture may lead to urethral injuries in 10% of patients. The type of urethral injury varies but can broadly be classified as simple or complex. Literature about the definition and management of complex pelvic fracture urethral injuries is improving. Internet and air travel are shrinking the world and because of this, urologists across the globe now have access to the experts with regards to the management of pelvic fracture urethral injuries. Due to the increase of cars and vehicles in many countries, an increase in pelvic fracture urethral injury (PFUI) is seen. The aim of this article is to make the urologist aware of the various scenarios of complexity in PFUI's and give tips on how to solve the problem locally. Complex pelvic fracture urethral injuries were first described in 1977 by Turner Warwick [1]. He proposed three scenarios:

1. Gaps greater than 2 cm with dense scarring
2. Strictures with extravasation, fistula, false passage or diverticulum
3. Extensive damage involving the bladder neck.

Korotim [2] expanded the definition to include patients with urinoma. Kulkarni et al. published their experience from India, which is a tertiary

referral centre for such complex cases [3]. They expanded the definition to include the following:

1. Multiple failed prior urethroplasty (re-redo)
2. Ischemic narrowing or necrosis of the bulbar urethra
3. Boys aged <12 years
4. Girls aged <12 years with associated urethrovaginal fistula
5. Double block at bulbo membranous junction and bladder neck – prostate
6. Recto urethral fistula
7. Incontinence due to bladder neck injury
8. Patients who have concomitant posterior urethral injury with anterior urethral strictures

22.2 Patients and Methods

Our tertiary referral institute has a maintained database with prospective follow up from 1995 to 2018. It is a GURS recognised fellowship-training centre with an experience of more than 4379 cases of urethral reconstruction performed to date, of which 1307 cases were PFUI. The age of patients ranged from one to 79 years and the mean follow-up was 68 months with a range of 6–175 months. Data was included so as to have a minimum follow up of 6 months (December 2016 was the cut off).

Due to varying geographic locations including international locations, follow up by the referring

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urologist was required. We have used internet-based applications like email and WhatsApp to our advantage. This has been significant progress, because the patient can be followed up from his or her home.

Pre operative assessment includes voiding cystourethrography (VCUG) and retrograde Urethrography (RGU). Few patients underwent MRI imaging of the pelvis prior to surgery.

We have developed a new protocol for MRI imaging for PFUI, which has now become standard protocol for MRI imaging in PFUI at our institute, which was presented recently at the AUA [4]. We routinely advocate penile Doppler in adults to document the flow in the dorsal penile and cavernosal arteries. Patients may have vasculogenic impotence, which can also lead to urethral ischemia.

Intraoperative we perform Urethroscopy and cystoscopy. Usually a 14 Fr suprapubic catheter (SPC) is used, hence routine cystoscopy sheaths (17 Fr and above) cannot be used easily. We use an Ureteroscope and Mini Nephroscopes for all our urethral scopes. We have found a broken Foley tip and stones in the bladder due to long term SPC which merits intraoperative endourology. The visual appearance of the bladder neck is documented. Standard surgical steps of the progressive and elaborate approach are used for performing tension free urethral anastomosis. At our institution success is defined as freedom from dilatation and instrumentation.

22.3 Results and Discussion

Results are discussed separately according to the subcategories of complex PFUI.

22.3.1 Redo and Re-redo Urethroplasty

This category includes patients with long gaps, intraprostatic injury and rare cases of urethra anastomosed to bladder neck and other scenarios (Fig. 22.1b–d). We have included patients with more than two prior attempts at Urethroplasty.

These patients can be very young, but can also include adults who have been on SPC for more than a decade. Therefore, after anastomotic urethroplasty, sometimes bladder – SPC tract closure is also necessary. The overall success rate of these cases is 74.75% as compared to primary cases which is 84.2% over the same period of time (Table 22.1).

We sub-classified the pelvic fracture urethral injuries in three categories: 1. primary; 2. one failed urethroplasty; 3. two or more failed urethroplasties. The results, analysis, and outcomes are being published soon. The reason why urethroplasty fails is a common question in the mind of all urologists. We wish to share our findings below.

1. In anastomotic urethroplasty we mobilise the bulbar urethra and anastomose it to the proximal urethra/posterior urethra. ICUD defines bulbar urethra as that part which is behind the bulbospongiosus muscle. If we need to stretch the urethra in long gaps, we need more length. This can only be achieved if the bulbar urethra is mobilised to the penoscrotal junction. Mobilisation beyond the penoscrotal junction would cause chordee. The commonest finding in our series is inadequate mobilisation of the bulbar urethra (63%).
2. Optimal scar excision is the key to success. In our experience the previous surgery involved suboptimal scar removal. This scar tissue either prevents the identification of a normal healthy prostatic urethra or causes constriction and narrowing at the site of the bulbo-prostatic anastomosis.
3. Inferior pubectomy is the key to tension free anastomosis in successful urethroplasty when needed. Koratim published an index to measure the need for a pubectomy [5]. Mundy et al. suggested one of the limiting and unpredictable steps is the time taken to access the posterior urethra [6]. Our subset of patients needs an inferior pubectomy more often. The rate of inferior pubectomy is much higher than reported in western experience [7]. We attribute this to anthropometric differences, pelvic structure, penile length and mechanism

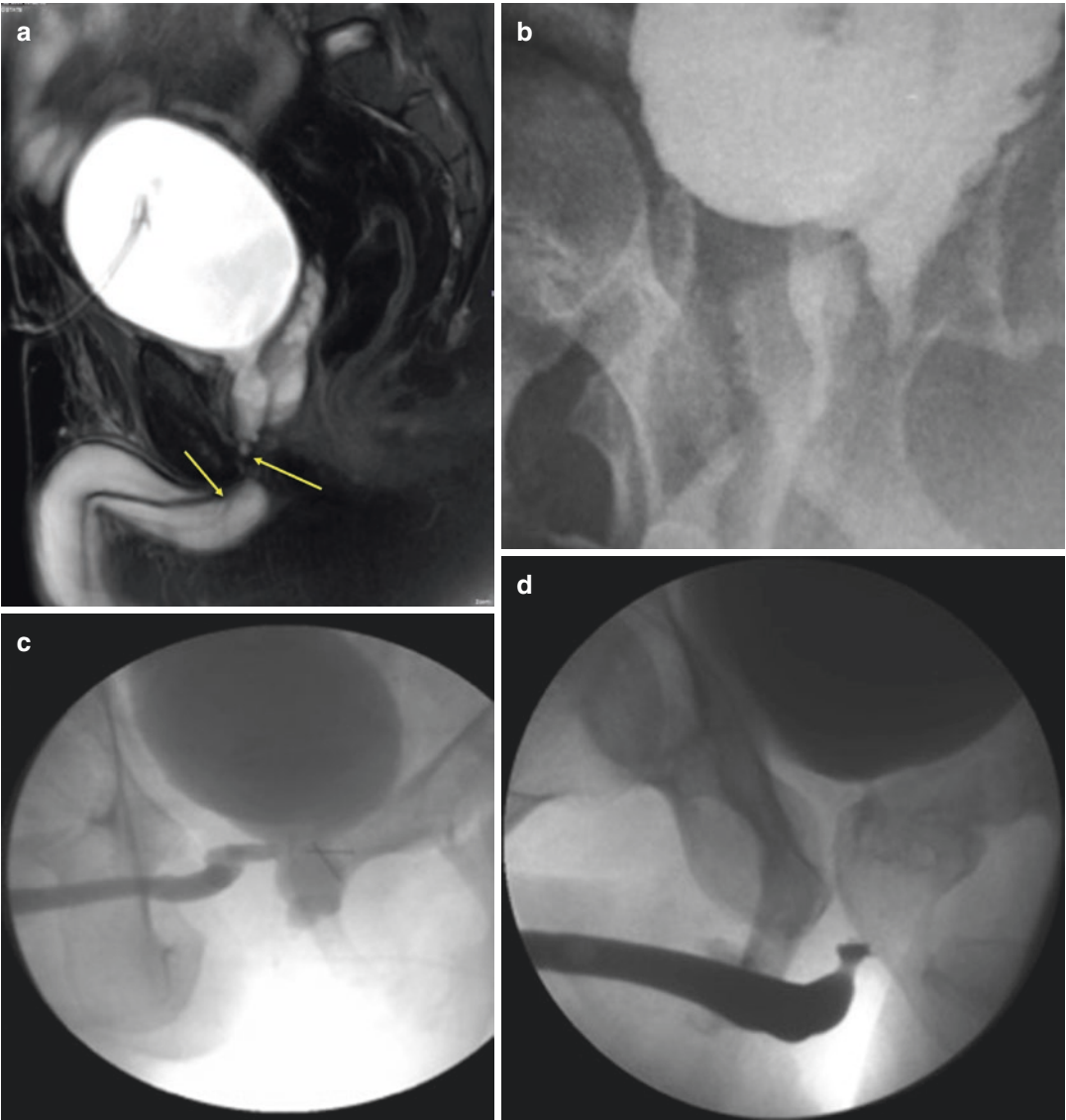


Fig. 22.1 (a) Our modified protocol of MRI in PFUI. (b–d) RGU/MCU showing a false passage, urethra connected to the bladder and intraprostatic injury

Table 22.1 The extent of dissection and success rates in redo urethroplasty

Step	Success rate
1: Bulbar mobilization	74.2%
2: Crural separation	91%
3: Inferior pubectomy	74.4%
4: Supracrural rerouting	81.8%
5 & 6: Abdominal approach without or with omental wrap	87%

of injury [8–10]. Most of our referred cases did not have an inferior pubectomy and this could be a contributing factor to the failure. Overall, our success rates of 84.2% and 74.75% for primary and repeat cases, respectively, were comparable ($P = 0.156$).

One unique situation is patients who have had laser urethrotomy for PFUI. This procedure is seldom successful. Many are on self-catheterisation.

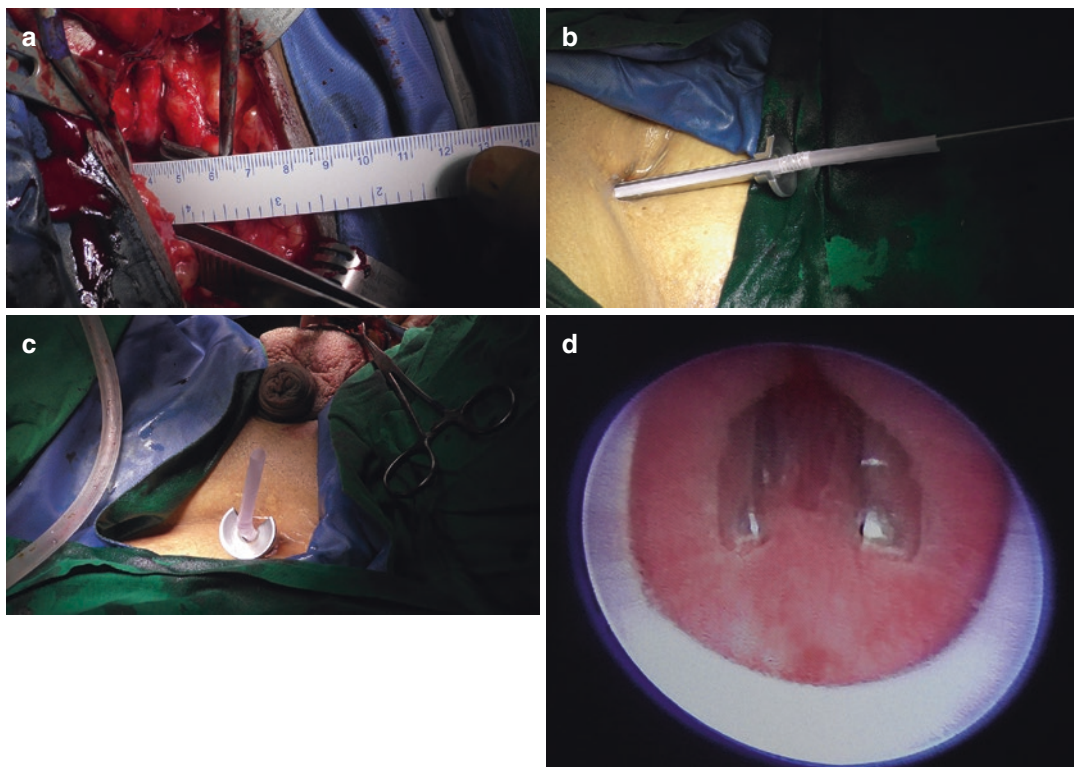


Fig. 22.2 (a) Intraoperative picture showing the depth of the posterior urethra. (b–d) Use of an intraoperative SPC tract made with a trocar, inserting a straw, ureteroscope demonstrating the bladder neck

This subset of patients merit anastomotic urethroplasty as a permanent cure. Intraoperative we find significant scar tissue. The scar prevents the urethra from distending during voiding and hence these patients need self-catheterisation. Scar excision is an essential step in urethroplasty. Usually there is no SPC and hence accessing the posterior urethra is not possible. We have devised a novel technique where intra operative we use a routinely available straw (used for cold drinks, coffee etc.) to be inserted through the trocar and then a SPC scope is performed with a 6 Fr Ureteroscope (Fig. 22.2b–e).

22.3.1.1 Tips for Redo Anastomotic Urethroplasty for PFUI

1. Dissect the urethra to the penoscrotal junction.
2. Use a mastoid retractor for the bulbospongiosus muscle.
3. Babcock's forceps should be applied on the bulb to lift it from the perineal body.

4. At times a retrograde bougie or a flexible ureteroscope passed through the SPC tract may not be felt in the perineum. In such a situation, inserting the index finger in the rectum helps locate the bougie in the prostatic urethra.
5. The membranous urethra should preferably not be spatulated.
6. Intraoperative endoscopy is imperative to identify the posterior urethra.
7. Use a knife to dissect the corpora. Electro dissection should be avoided.
8. Bending the tip of the electro cautery at a right angle facilitates easy periosteal elevation.
9. Tension free anastomosis is mandatory.

22.3.2 Bulbar Urethral Necrosis

Primary anastomotic urethroplasty involves transection of the bulbourethral arteries. The mobilised bulbar urethra depends on retrograde flow from the glans and dorsal penile arteries. Patients

with poor retrograde blood flow develop ischemia of the mobilized bulbar urethra, which can manifest as stenosis or complete loss resulting in bulbar necrosis. This condition was most probably classified as “long gaps” or “unsalvageable” after failed urethroplasty [11, 12]. In 1986 Turner Warwick described this as spongionecrosis of the bulbar urethra [13].

Concomitant Hypospadias is challenging. Improper pubectomy causing damage to the dorsal penile arteries can lead to bulbar urethral necrosis. Periosteal elevation is key to avoid injury to the arteries, which are lateral to the dorsal penile vein. Patients with this complex problem require vascularized flaps for augmentation (in stenosis) or substitution (in necrosis) (Fig. 22.3b, c). There are many options available that are practised at our high-volume centre, but we will focus on a specific few. The rest can be traced from previously published articles on the same topic:

1. **Pedicled preputial tube (Video):** Inner circumcision is performed deep to the dartos and outer circumcision is performed deep to the skin but superficial to the dartos. As a result the prepuce is mobilized based on the dartos pedicle. It is incised ventrally and transposed to the perineum, tubularised and substitution urethroplasty performed.
2. **Pedicled penile skin flap (Q flap and McAninch Flap)** in cases where the prepuce is absent.
3. Mundy et al. have used various bowel segments, most commonly sigmoid as substitution urethroplasty. This is called as Enterourethroplasty [13].
4. The use of a buccal mucosa graft (BMG) dorsally and flap ventrally (this can be performed provided the inferior pubectomy is not required to identify the posterior urethra. An intact corpora positioned in the midline is required to quilt BMG).

The details of the success rate as per choice of management have been highlighted in Table 22.2.

The use of skin flaps can lead to diverticulum formation, which may need reduction urethro-

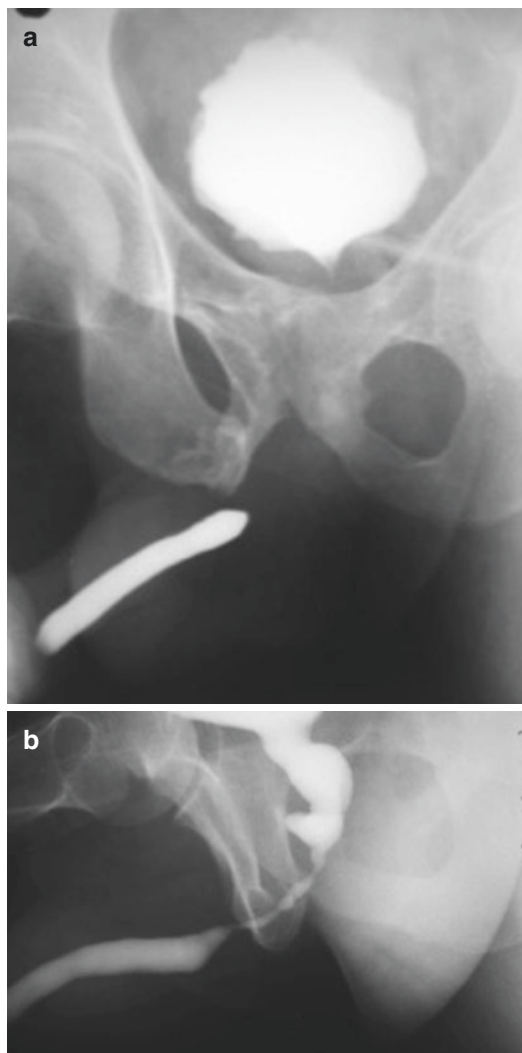


Fig. 22.3 (a, b) Urethrograms showing bulbar urethral necrosis and bulbar urethral stenosis

plasty at a later date. This is due to stretching of the skin-lined urethra. The pedicled preputial tube acts as a conduit but does not have the viscoelastic properties of a normal urethra. The overall success rate of treating bulbar necrosis was 76.67%.

Algorithm for bulbar necrosis: We suggest using preputial skin flap as a first choice. If the prepuce is absent, urethroplasty with penile skin flap is recommended. Enterourethroplasty with sigmoid colon is a good option but needs technical expertise.

Table 22.2 Bulbar urethral necrosis management and success rate

Procedure	Number	Success rate
Pedicled preputial tube and “Q” flap	74	86.4%
Oral mucosa flap	10	58.56%
Pedicled prepuce as onlay augmentation with dorsal BMG	16	89.12%
Scrotal drop back	6	33.33%
Enterourethroplasty	2	100%
Forearm flap with micro vascular anastomosis	3	100%
Pedicled anterolateral thigh flap	2	50%
Dorsal BMG with ventral BMG on Gracilis muscle transposed to perineum	2	100%
Total number	115	76.67%

22.3.3 Boys Aged <12 Years

PFUI in young boys is challenging. This is mainly because of underdeveloped pelvic bones. This leads to a long gap. The urethra is also small. Flynn et al. [14] reported the need for elaborate procedures. Boys might have an underdeveloped glans, resulting in inadequate retrograde blood flow. Hence, the best chance of success is at the first repair. Common sites of injury in children include supraprostatic, transprostatic, prostatomembranous, and bulbomembranous junction [15]. We have operated on 80 boys with a mean age and range of 10.78 (1–12) years. Of the 80 children, 36 were redo cases while 44 had a primary repair. Inferior pubectomy is needed more often than in adults (Fig. 22.4a). The bulbar urethra has yet to develop fibroblastic properties, and a simple bulbar mobilization is unlikely to provide the length needed for a tension-free repair in children. Transpubic/abdominal approach was required in 31% of the time, compared to 9% in adults. We wish to inform our readers that crural separation, pubectomy and the transpubic approach are easier said than done in kids where the size of urethra and prostate is small. Only experts should do urethroplasty.

22.3.4 Girls Aged <12 Years

PFUI in females is rare with an incidence of 4–6% [16, 17]. Road traffic accidents and crush injuries (due to earthquakes) have been the most common aetiology of PFUI in females referred to

us. The injury can be at the level of the bladder neck, proximal, mid or distal urethra.

In our centre 11 young girls and five adult females were operated. Adult females are excluded from this review. Girls cannot be approached by the transvaginal route unless the injury is distal. All except one required an abdominal approach. There is usually a distal urethrovaginal fistula, which can be missed unless looked for (Fig. 22.4b).

Endoscopic evaluation is important. Standard steps included identifying the bladder and a posterior pubectomy. Incising the bladder can be avoided. A scope or bougie through the SPC tract can be guided to the bladder neck. Dissection is done to get the two urethral ends and identify the urethrovaginal fistula. The vagina is closed and the urethral ends are anastomosed over a periurethral Foley catheter.

Seven girls had a successful outcome, one required redo surgery and one required dilatation of the urethra. We had two girls with distal injury. They had vaginal stenosis with hard scar tissue. The meatus usually becomes hypospadiac and opens in the vaginal wall. Due to introital narrowing urine collects in the vagina presenting as incontinence. We performed a lateral episiotomy using sharp dissection. On the day of sending this article for publication, we were engaged in a complex female urethroplasty with complete proximal urethra loss, bladder neck transection, vaginal stenosis, and a distal urethra vaginal fistula with the pubic bone fixed in the midline with screws and a plate that had to be cut (Fig. 22.4c).

22.3.5 Double Block (Video)

These male patients have injury at both sphincter mechanisms (the bladder neck prostate and bulbomembranous level). Mundy and Andrich [18] reported 15 patients with bladder neck injuries of

whom two had double block at the bulbomembranous and bladder neck prostate level. They termed this as a “sequestered prostate”. Kulkarni et al. reported five patients with double block [3]. Our experience to date includes 11 patients (Fig. 22.4d). These injuries are suspected during

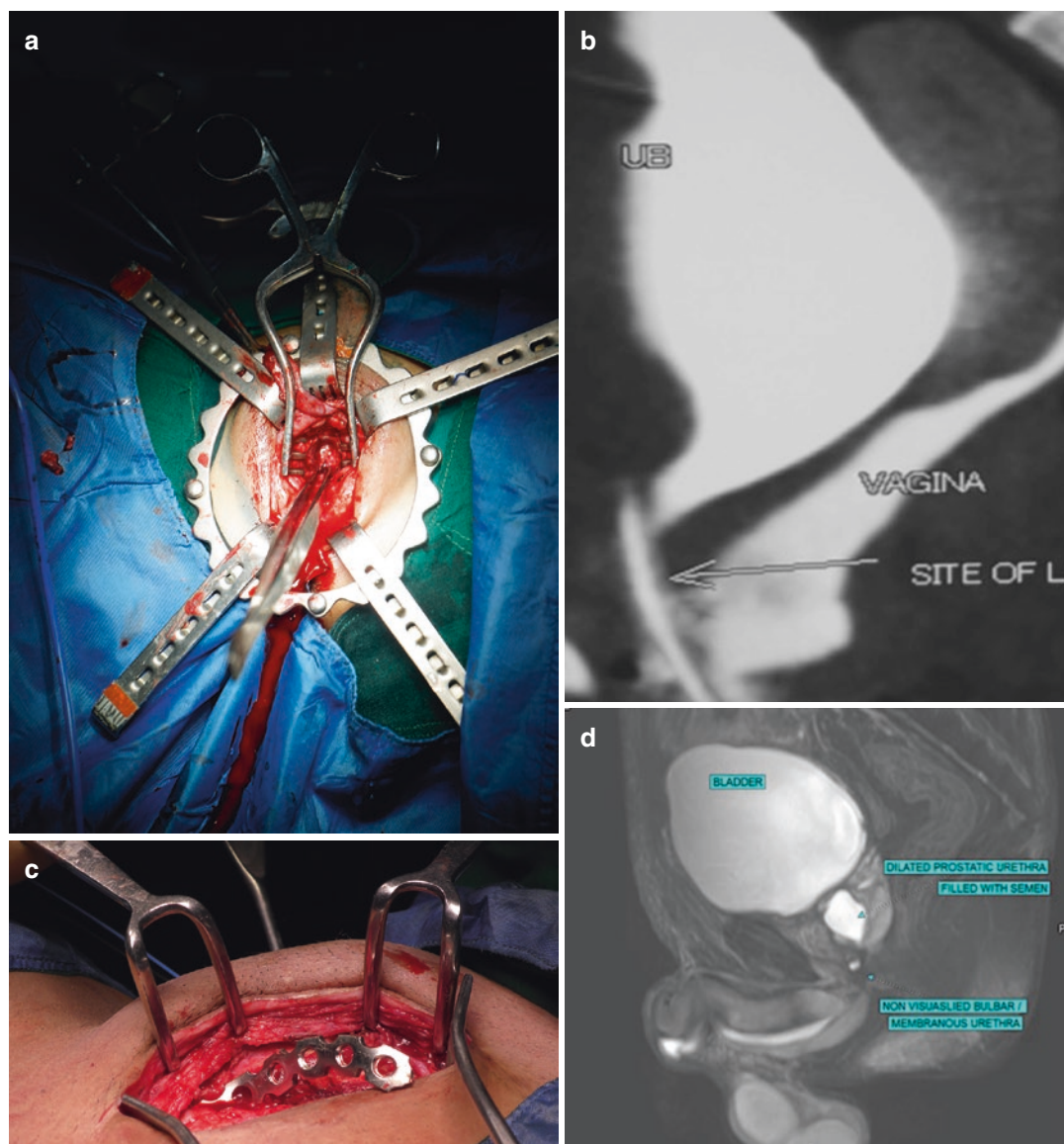


Fig. 22.4 (a) Urethroplasty in a young child aged three with crural separation and inferior pubectomy. (b) CT scan in a female with PFUI showing urethrovaginal fistula. (c) Plates inserted on the pubic bone which merits removal during transpubic urethroplasty in a young girl with PFUI. (d) MRI in a young boy showing double block

at the bulbomembranous junction and the bladder neck prostate junction. (e) Rectourethral fistula associated with PFUI. (f) Open bladder neck seen on cystoscopy from SPC tract. (g) Tear drop bladder deformity seen on cystoscopy from SPC tract. (h) Urethrogram showing anterior urethral stricture with pelvic fracture distraction defect

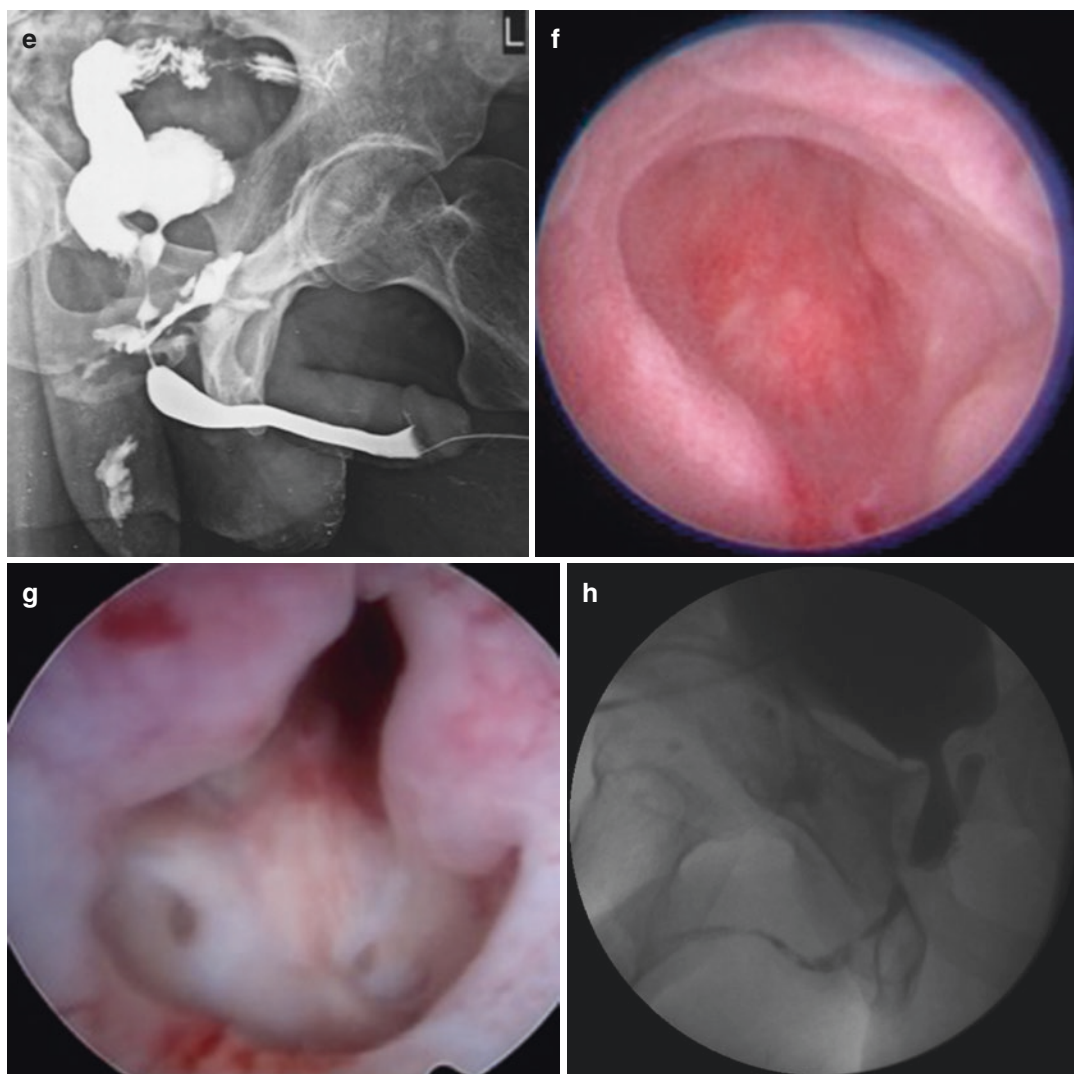


Fig. 22.4 (continued)

preoperative VCUG and RGU by non-delineation of the prostatic urethra. In adults, semen accumulates and the prostate feels/appears like a cyst. MRI is the key to diagnosis.

We have treated eight patients with double block (three adults and five children). Two patients were incontinent which made us modify our surgical steps to preserve the continence mechanism. According to Mundy et al., 85% of PFUI patients have a normal functioning external sphincter. In double block, the bladder neck may not contribute to continence. We presented a

video abstract at the AUA highlighting the steps to achieve continence:

The standard steps in our unit for such cases include:

1. Transect the bulbar urethra at the site of the block via the perineal approach.
2. Abdominal incision – identify the bladder neck, incise.
3. The prostate will appear as a cyst: insert the needle, guidewire, dilate and perform intra-prostatic scope with an ureteroscope.

4. Open the membranous urethra over the ureteroscope guidance.
5. Avoid spatulation of the membranous urethra.
6. Bladder neck–prostate and bulbomembranous anastomosis: omental wrap.

Continence was achieved in two adults and five children. Three children have nocturnal enuresis and one adult merits an artificial sphincter.

22.3.6 Rectourethral Fistula

These patients have a diverting colostomy with SPC. Occasionally rectourethral fistula (RUF) can be iatrogenic due to prior attempt at urethroplasty (Fig. 22.4e). In a review of 573 patients with a pelvic fracture, Fu et al. [19] recognized iatrogenic injury to the rectum in 5% of cases. These were repaired primarily, with no fistula, but it highlights the risk of RUF in an unrecognized injury from PFUI management.

Surgery for rectourethral fistula is performed in two steps:

1. Urethroplasty with closure of RUF and intervening tissue barrier.
2. Colostomy closure

Patients can have two presentations: a blocked urethra with RUF, or a normal urethra with RUF. If the urethra is normal, then the approach should be by half-moon incision around the anal canal from 3 to 9 o'clock as used in oncosurgery. When the urethra is involved, cystoscopy should be used to pass a guide wire from the urethra to the rectum. Standard perineal steps of urethroplasty are applied. The RUF is identified, the edges refashioned and then closed. Intervening tissues can be local or specialised flaps. We have used gracilis, surrounding perineal fat and one limb of bulbospongiosus muscle as local vascular intervening tissue. However, a major advancement has been our technique of laparoscopic omentoplasty whereby omentum is transferred to the perineum avoiding a transpubic approach [20].

Eleven patients were cured at first attempt and two required redo surgery. Closure of colostomy was done in nine patients. Two patients with rectal stenosis underwent anal pull through surgery. One patient had an end colostomy and needed formal abdominal exploration to restore bowel continuity. Our results show that traumatic RUF in the context of pelvic fracture can be managed via a perineal approach. We faced two challenges. Concomitant rectal stenosis does not allow for a finger to be inserted in the rectum. We use this step often for a high riding prostate when bougie/flexible cystoscope cannot be accommodated in the perineum. In such patients it's a challenge to find posterior urethra when it is high. Few patients have rectal sphincter injury, making subsequent colostomy closure debatable of possible faecal incontinence. They merit special attention by gastrointestinal surgeons. This can avoid complications encountered on using a perianal/posterior sagittal approach.

22.3.7 Bladder Neck Injury-Incontinence

In the review done by Mundy et al. they found that 85% of patients of PFUI have a functioning external urethral sphincter mechanism after successful anastomotic repair [21]. In those where the injury is membranous, continence primarily depends on the bladder neck sphincter mechanism. Patients who have a closed bladder neck can be assumed to have normal function postoperatively. We see patients with a wide-open bladder neck possibly due to neuropraxia (Fig. 22.4f). Meticulous bulbomembranous anastomosis is the key to continence [22]. In redo cases this is challenging. Switchblade injury by pubic bone can cause a teardrop deformity, where there is trauma to the bladder neck at 12 o'clock (Fig. 22.4g). This is usually due a fragment of the fractured pubic bone impinging on the bladder neck. In five patients we excised the bone and refashioned the bladder neck. Three patients are continent and two are awaiting artificial urinary sphincter insertion. We have not experienced good results with

Table 22.3 Anterior urethral stricture and PFUI

Primary pathology	Number	Anterior stricture site	Success
1. Bulbar with PFUI	3	Dorsal onlay with anastomotic	2/3
2. Panurethral with PFUI	4	Pan urethral Kulkarni technique with anastomotic	4/4
3. Penoscrotal stricture with PFUI	2	Onlay augmentation with anastomotic	1 developed fistula

scar excision around the bladder neck and omental wrapping. In our experience only patients with tear drop deformity of the anterior bladder neck benefit from bladder neck reconstruction.

22.3.8 Posterior Urethral Injury with Anterior Urethral Strictures

We often see patients with lichen sclerosis along with PFUI. The cause of strictures in the anterior urethra can be due to previous attempts at realignment, catheter and endourological procedures.

The anterior urethral strictures urethra can be bulbar, penile or panurethral. Ischemia due to injury could also be a possible cause for concomitant strictures. Only one paper in the literature describes the management of such strictures. However, the authors use dilatation for more than 50% of patients with a failure rate of 44% [23]. A staged urethroplasty has been performed in the majority of cases.

Our approach has been to give the patient a single stage, vessel-preserving urethroplasty. Kulkarni et al. published the technique of one-sided dissection for the bulbar urethra and panurethral stricture [24]. The urethra is mobilized dorsally across the midline. There is no circumferential mobilization. As a result the neurovascular tissue on one side (usually the right side of the patient because the majority of surgeons are right-handed) remains intact. This is a useful adjunct in managing complex cases of PFUI. Important steps include (Table 22.3)

- One-sided dissection of the bulbar urethra, which maintains the lateral neurovascular supply.

- The most proximal part of the bulbar urethra can be transected with minimal mobilization. If possible one the bulbourethral artery is preserved on one side.
- Augmentation of the anterior urethra with buccal graft depending on the location of the stricture.
- Bulbomembranous anastomosis.

22.4 Conclusions

Surgical experience grows each day. Complex pelvic fracture urethral injuries need management by an expert. We believe that the key to surgery lies in the mind and all we need is good execution. Complex problems will arise and we need to find solutions to such problems. It is disheartening to see patients having SPC for a long term for want of an expert's management. The purpose of this article is to emphasize the fact that solutions exist to each complex problem. From the three categories described by Turner Warwick, expanded to eight by us, the complexity is bound to grow as experience grows. The internet, travel, conferences and journals are ways in which one can train oneself to understand such problems.

Key Summary Points

- Anastomotic urethroplasty for complex PFUI should be done by experienced surgeons at high volume centres.
- The bulbar urethra should be mobilised to the penoscrotal junction to achieve tension free anastomosis.

- Optimal scar excision and inferior pubectomy (when needed) should be performed.
- Young boys tend to have long gaps and a small urethra and prostate. They should be referred to experts.
- Girls with PFUI usually have distal urethra vaginal fistula. They merit an abdominal approach with posterior pubectomy. The majority of girls remain continent.
- Double block at the bladder neck- prostate and membranobulbar urethra is uncommon but possible. Identifying the membranous urethra through intraprostatic scope and performing bulbomembranous anastomosis can preserve continence in such patients.
- RUF should be approached through the perineal route with locally available tissues or the gracilis muscle as interposition. Our technique of laparoscopic omentoplasty is a novel advancement of the minimally invasive approach.
- Tear drop deformity of the bladder neck needs reconstruction with excision of the impinging bone chip.
- Patients with concomitant anterior and posterior urethral strictures can be managed easily with our approach in a single stage.
- Do not hesitate to take help from experts in the management of complex PFUI.

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Surgical Reconstruction of Post-TURP Urethral Strictures

23

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23.1 Introduction

Lower urinary tract symptoms (LUTS) secondary to benign prostatic hyperplasia (BPH) affect men as early as the fifth decade of life, and the prevalence of symptoms increases with age [1]. Most patients are initially treated with medical therapy consisting of alpha blockers and/or 5-alpha reductase inhibitors. Patients with persistent symptoms, despite optimal medical therapy, are candidates for surgical intervention. Additionally, surgical intervention is indicated for patients with urinary retention, renal failure, recurrent urinary tract infections, bladder stones, and recurrent hematuria.

Transurethral resection of the prostate (TURP) is the gold standard for the surgical management of benign prostatic obstruction. As with any surgical intervention, there are risks for complication including urethral stricture disease. The incidence of urethral stricture disease after transurethral resection of the prostate can be as high as 9.8% [2.2–9.8%] [2]. According to Rassweiler et al., the most common locations for strictures after TURP are the fossa navicularis and the bulbar urethra. The etiology of these strictures are

related to either the difference in size between the fossa navicularis and the resectoscope or thermal injury due to leak of current causing urethral injury that later results in a stricture [3]. A recent multivariate analysis by Tao et al. demonstrated that urethral mucosa rupture and continued infection were also risk factors for urethral stricture after TURP leading to possible panurethral strictures [4, 5].

23.2 Evaluation

Patients with recurrent obstructive LUTS (weak urinary stream, straining to void, hesitancy and incomplete bladder emptying) within the first year after TURP merit evaluation for urethral stricture disease as the cause of their symptoms. Initial evaluation should consist of a complete history and physical exam with emphasis on surgical history, urethral instrumentation, and any significant factors that may represent a contraindication for surgical intervention and buccal graft harvest. Use of the International Prostate Symptom Score (IPSS) questionnaire and uroflowmetry at the time of initial evaluation are also helpful tools to better characterize the patient's symptoms.

Once the diagnosis of urethral stricture disease is suspected, evaluation of the urethral anatomy is warranted. Initial evaluation of the urethral anatomy can be a challenge since patients can

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Fig. 23.1 VCUG showing a tight fossa navicularis with mild irregularities within the bulbar urethra. (Imaging courtesy of Joseph Pariser, MD)

have multifocal strictures. It is necessary to ensure that proximal strictures are recognized in the presence of distal strictures. At our institution, patients are evaluated with a retrograde urethrogram and a small caliber ureteroscope to ensure complete evaluation of the urethra prior to making treatment recommendations. Voiding cystourethrogram (VCUG) is also an excellent tool (Fig. 23.1).

23.3 Surgical Reconstruction Techniques

As stated before, patients with urethral stricture after TURP pose a diagnostic and management challenge due to the possibility of multifocal strictures, the proximity of proximal bulbar strictures to the striated sphincter and/or in some cases, involvement of the entire anterior urethra. It is important to recognize that proximal bulbar strictures have been misnomered in the past as true membranous urethral strictures when in fact stenosis that affects the membranous urethra is uncommon in the absence of radiation [6].

There is a risk of incontinence associated with the surgical repair of proximal bulbar strictures, and it is relatively high since urinary con-

tinence in men after TURP is mainly achieved by the striated sphincter. Any dissection near the sphincter theoretically increases the incidence of iatrogenic incontinence. Some authors have suggested a sphincter-sparing technique, as described by Gomez, is the ideal technique for short post TURP proximal bulbomembranous strictures [7]. Recently, Kulkarni et al. suggested that a ventral approach was technically better for post TURP strictures because it provides the ability to incise the mucosa without affecting the sphincter. This is the approach we use at our institution [8].

Although the most common locations for post TURP strictures are within the fossa navicularis or the bulbar urethra, patients can develop strictures anywhere along the urethra [8]. Most of the surgical techniques used at our institution for strictures after TURP are single-stage procedures that are used for idiopathic urethral strictures. Staged procedures are reserved for cases with extensive spongiofibrosis or recurrent strictures. Most of the techniques used are reviewed in previous chapters, thus we will briefly discuss the techniques used at our institution and provide some surgical pearls.

23.4 Urethral Meatus and Fossa Navicularis Strictures

Most patients with isolated stenosis or stricture of the distal penile urethra will describe their symptoms as an obstruction near the glans. If preoperative evaluation reveals an area of stricture 1 centimeter (cm) or less, patients are initially treated with a meatotomy. At 3 months, voiding symptoms and satisfaction with the cosmetic results are reassessed. If patients are not satisfied with the cosmetic results of their primary surgery, a staged repair with buccal graft can be considered.

Strictures that involve the fossa navicularis but are no longer than 4 cm are managed with a transurethral ventral buccal mucosal onlay as described by Nikolavsky et al. [9]. In our experience, this technique has given excellent cosmetic results and has minimized the complications associated with a staged repair.

Surgical steps/pearls for meatotomy

Urethral meatus is incised ventrally with excision of the fibrotic tissue if necessary

Neomeatus is calibrated to 24 French (Fr) to ensure urethral patency

Mucosal edges are approximated with interrupted 4-0 Polyglactin sutures

Pearl: Patients are allowed to void per urethra in the immediate postoperative period and do not require an indwelling catheter

Surgical steps/pearls for a transurethral ventral onlay for fossa navicularis strictures

A transurethral ventral urethrotomy is performed after adequate exposure is created with traction sutures at the 12, 4 and 8 o'clock positions on the glans penis

Once the ventral urethrotomy is performed, the fibrotic tissue is removed between the 4 and 8 o'clock position. This is done until the proximal lumen is at least 24 Fr

Pearl: Removal of the fibrotic tissue is essential to create the space necessary for the buccal graft

A buccal mucosal graft is parachuted into the defect and fixed transurethrally using 6-0 Polydioxanone sutures

23.5 Penile Urethra

Patients with isolated stenosis of the penile urethra without involvement of the fossa navicularis or distal strictures that are longer than 4 cm but not beyond the penoscrotal junction are treated with a dorsolateral buccal graft urethroplasty using a penoscrotal approach as described by Warner et al. [10].

Surgical steps/pearls for isolated penile urethra or stricture distal to the penoscrotal junction

A transverse incision is performed at the penoscrotal junction and the penis is inverted through the incision in order to expose the penile urethra (Fig. 23.2)

Once the penile urethra is exposed, the urethra is dissected from the corpora from left to right without complete mobilization of the urethra sparing the contralateral blood supply

Once mobilization is completed, a dorsal urethrotomy at the 12 o'clock position is performed at the level of the stricture

Pearl: The urethrotomy is extended by at least 0.5 cm into healthy-appearing urethra

A buccal mucosal graft is placed over the corpora cavernosa and the urethra is closed over the graft. (Fig. 23.3)

Urethral catheter is left for 14 days and a VCUG is performed to confirm urethral healing before allowing patients to void per urethra

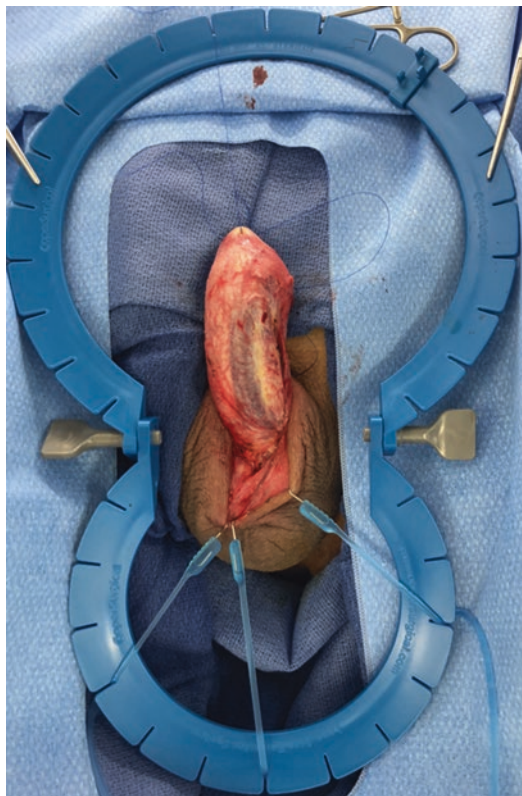


Fig. 23.2 Penile urethra exposed through a penoscrotal approach. (Photo courtesy of Jonathan Warner, MD)

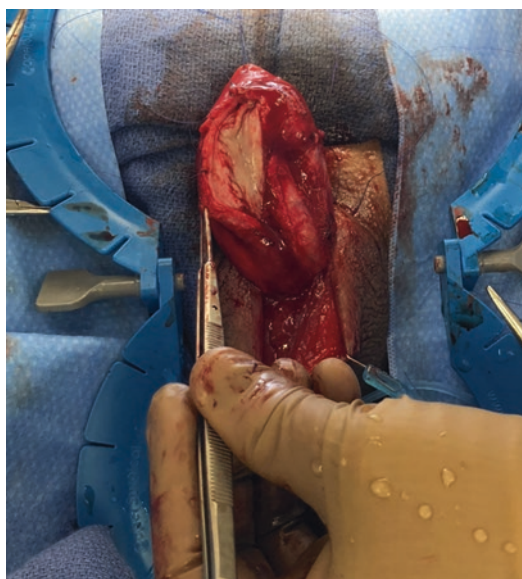


Fig. 23.3 Dorsolateral graft placed over the corpora cavernosa for penile stricture. (Photo courtesy of Jonathan Warner, MD)

23.6 Proximal Bulbar Urethra

The possibility of iatrogenic urinary incontinence when treating proximal bulbar urethral stricture may represent a treatment dilemma. Repeat endoscopic management might be the treatment of choice to reduce the probability of incontinence. Unfortunately, there is no strong data to support which type of technique (excision and anastomosis, dorsal onlay buccal graft or ventral onlay buccal graft) decreases the incidence of post-operative urinary incontinence for the treatment of strictures that are near the striated sphincter. Gimbernat et al. reported that no new incontinence was found after dorsal onlay for patients with membranous strictures [11]. Blakely et al. also found that the dorsal approach had no incidence of de novo incontinence [12]. Although some authors have described success with a ventral approach, no studies have shown their outcomes with regards to incontinence and strictures secondary to TURP [8, 13] (Fig. 23.4).

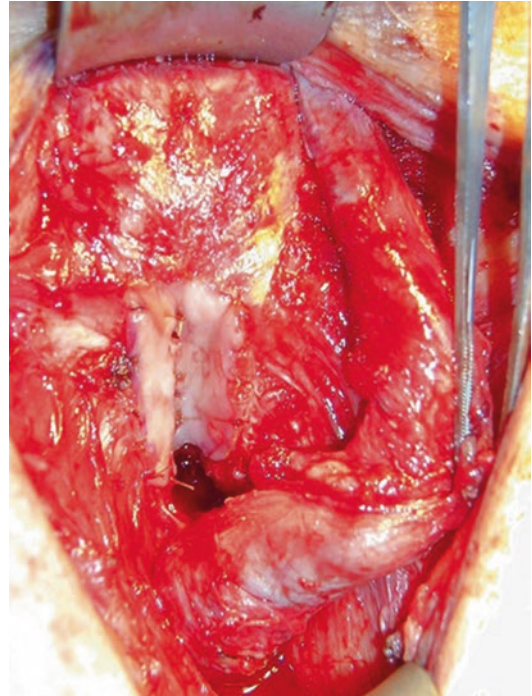


Fig. 23.4 Dorsal onlay buccal graft for proximal bulbar stricture

Surgical steps/pearls for proximal bulbar strictures

Patients are placed in an extended dorsal lithotomy position. We have found that this position facilitates access to the proximal bulbar urethra when compared to standard lithotomy

A midline perineal incision provides sufficient exposure to the proximal anterior urethra

The bulbospongiosum muscle is open at the midline with minimal dissection to preserve the subcutaneous fat layer in order to minimize inadvertent nerve injury

A ventral urethrotomy is performed at the level of the stenosis over a 22 Fr bougie. The urethrotomy is extended beyond the stricture by providing traction at the time of incision

Pearl: We have found that providing traction using Gerald tissue forceps with teeth can facilitate extending the urethrotomy up to the verumontanum and spare the muscular fibers of the striated sphincter

Proximal urethral lumen is then calibrated with a 30 Fr bougie and a buccal graft is parachuted in as described by Barbagli [14]. At our institution, we have been successful placing proximal sutures using a RB-1 needle without having to mold the needle into a J-shape needle

Urethral catheter is left for 10 days and a VCUG is performed to confirm urethral healing before allowing patients to void per urethra

23.7 Panurethral Strictures

Panurethral strictures may represent technical difficulty because of the extent of the disease, and in rare cases may be multifocal in nature with spared segments of the urethra e.g. short proximal bulbar stricture and long penile stricture. We have found that long panurethral strictures are best treated with a dorsolateral buccal graft through a perineal incision and penile invagination as described by Kulkarni et al. [15]. In rare cases, patients may present with a multifocal stricture that have normal appearing urethra between lesions. We have been able to treat both strictures in one procedure by performing a dorsolateral buccal graft urethroplasty for the distal stricture and a ventral buccal graft for the proximal stricture.

Surgical steps/pearls for panurethral strictures

Patients are placed in a standard dorsal lithotomy position. A guidewire is inserted through the urethra at the time of surgery

Surgical steps/pearls for panurethral strictures

A midline perineal incision provides sufficient exposure to the entire anterior urethra

The bulbospongiosum muscle can be retracted without the need of splitting the muscle if the stricture is within the distal aspect of the bulbar urethra

Penile invagination is performed directly over the corpora spongiosum with the aid of sharp dissection using scissors. The plane of dissection should be under Dartos's fascia for adequate exposure

Once the penile urethra is exposed, the urethra is dissected from the corpora from left to right without complete mobilization of the urethra sparing the contralateral blood supply

Once mobilization is done, a dorsal urethrotomy at the 12 o'clock position is performed at the level of the stricture. If the stricture involves the urethral meatus, dissection is done as distally as possible within the glans penis and a 1 cm urethrotomy is done to facilitate exposure and graft placement

Pearl: A suprapubic catheter is placed and the urethral catheter is capped during the postop period

A buccal mucosal graft is placed over the corpora cavernosa and the urethra is closed over the graft [15]

Urethral catheter is left for 14 days and suprapubic tube is kept for an additional 2 weeks. A VCUG is performed to confirm urethral healing before allowing patients to void per urethra

fossa navicularis and the bulbar urethra the most common areas.

- It is important to perform a complete evaluation of the urethra prior to definitive treatment in order not to neglect proximal strictures in the presence of distal strictures.
- There is an increased risk of incontinence related to the surgical repair of proximal bulbar strictures especially in men after TURP.
- Further studies are required to determine which is the better approach for proximal bulbar strictures with regards to the risk of incontinence.
- Most of the surgical techniques used for strictures after TURP are techniques used for idiopathic urethral strictures.

23.8 Conclusions

Patients with urethral strictures after TURP are fundamentally treated in a similar fashion as idiopathic strictures. Additional studies, including randomized controlled trials, are necessary to determine which approach will provide better outcomes for patients with strictures near the striated sphincter. Multi-institutional collaborations will provide a higher number of patients in order to generate better conclusions.

Key Summary Points

- The incidence of urethral stricture disease after transurethral resection of the prostate (TURP) can be as high as 9.8%.
- Urethral strictures after TURP can be seen within the entire urethra being the

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Surgical Reconstruction of Membranous Urethral Strictures Due to Radiation

24

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24.1 Introduction

Radiation therapy has long been established as an important modality in the management of prostate cancer, with about 25% of men electing this as their primary therapy [1]. Radiation therapy offers those patients who are unwilling or unable to undergo more invasive treatments a useful option for controlling their disease. However, it has also given rise to a particularly complex urologic issue: radiation-induced stricture disease. These strictures prove significantly more difficult to manage than other forms of urethral stricture, with significantly increased rates of recurrence and complications after treatment.

As the field of radiation therapy continues to be a mainstay for management of multiple forms of pelvic cancer, including rectal cancers, complicated radiation-induced urethral stricture disease can be anticipated to remain a vexing issue for reconstructive urologists. In this chapter, we will examine the literature on reconstruction

of radiation-induced urethral stricture in male patients, including prevalence, pathogenesis, diagnosis, and current treatment options of these complicated strictures.

24.2 Prevalence of Radiation-Induced Urethral Strictures

Prostate cancer treatments, mainly radical prostatectomy and pelvic radiation, are associated with a significant risk of urethral stricture formation as well as other significant urologic complications such as hemorrhagic cystitis or fistula formation. The overall burden of radiation-induced urologic disease, when examined at a tertiary referral urology department in Australia, was found to account for 2.8% of their total hospital admissions, with 7.2% of emergency admissions being related to radiation-induced disease [2].

Brachytherapy (BT) and external beam radiotherapy (EBRT) are the two mainstays of radiation treatment for prostate cancer and are commonly utilized treatment modalities [1]. Stricture disease following prostate BT has been demonstrated to have an incidence range beginning at 1.7% and reaching nearly 32% in patients undergoing high-dose BT [3–8]. EBRT has also been found to have a 1.1–4.5% risk of stricture formation, which is significantly increased if combined with brachytherapy [3, 5, 8–10]. In 2006, Elliot et al. evaluated the risk of radiation-induced stricture

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incidence by analysing the CaPSURE database. The authors found that EBRT and BT had an overall stricture formation risk of 1.7% and 1.8% respectively, combination EBRT+BT had an overall risk of 5.2%. More recently, Awad et al. published a systematic review and meta-analysis including over 16,000 prostate cancer patients undergoing radiation therapy and found that 630 (3.9%) of these patients developed urethral strictures, with a pooled estimate period prevalence of 2.2% at a follow-up of 4 years [5]. The investigators reported that in combination EBRT+BT patients, the pooled prevalence estimate rose to 4.9%. Longer time to follow-up was found to increase the risk of developing strictures, as was the use of combination EBRT+BT compared to EBRT alone. In BT patients who develop strictures, it has been reported that 90–100% of these strictures occur in the bulbomembranous urethra and that they occur at a median of 2.2–2.4 years after implantation of BT seeds [5–8].

24.3 Pathogenesis of Radiation-Induced Membranous Urethral Stricture

In patients with prostate in-situ, radiation-induced strictures typically occur in the bulbomembranous region, as this area is under direct insult during EBRT or BT. Similarly, in post-prostatectomy patients who undergo salvage or neoadjuvant radiation therapy, stenosis or obliteration occurs at the vesicourethral anastomosis. Overall, it is acknowledged in the literature that one of the most important aspects of prostatic radiation therapy with respect to stricture development is the cumulative dose of radiation. High-dose rate brachytherapy combined with external beam radiation has the highest risk of stricture formation among radiation therapy modalities, reaching in some series 9–21%, while conformal and intensity modulated radiotherapy have the lowest possible rate of stricture, ranking between 1.7–4% [3–7, 10–12]. In addition, prior transurethral resection of the prostate and hypertension have been noted as patient risk factors [4, 6, 11]. Though most clinical reports do not stratify their patient's risk of stricture based on dosage, the direct effect of radiation dose scheduling has

been documented in the radiation oncology literature [4].

Radiation therapy induces a cycle of inflammation and healing that reduces existing vascularization via endothelial edema and thrombosis, and impairs neovascularization, leading to fibrous changes [13–15]. Pro-fibrotic cytokines, such as TGF- β , have been demonstrated to remain elevated in irradiated tissue up to 1 year after initial exposure [14]. As time wears on, irradiated tissue demonstrates late changes of atrophy and fibrotic contraction, with decreased wound-bursting strength compared to native tissue [13, 15]. Stricture tissue has been found to be comprised of a higher proportion of type I collagen than native urethral tissue, likely contributing to the non-compliant and obstructive characteristics of the fibrotic changes [16]. Irradiation prior to surgery has been demonstrated to have a clear dose-dependent effect on the ability of wounds to heal, primarily via damage to fibroblasts and their ability to proliferate and generate collagen [15]. This impairment of the wound-healing ability of native urethral tissue by prostatic radiation therapy is likely a significant risk factor stricture formation, particularly in those patients who undergo urethral instrumentation.

24.4 Evaluation of Radiation-Induced Stricture Disease

The initial evaluation of patients presenting with lower urinary tract symptoms following prostate cancer treatment should begin with a thorough physical exam and taking a careful history of the patient's previous urologic instrumentation and treatments with regard to potential radiation-induced urethral strictures. Patients should be queried about any prior urinary incontinence, stress or urge, as well as asked about prior or current use of pads. If the patient is currently incontinent, a 24-hour pad-weight test should be performed. It is important for patient counseling to assess their ability to produce volitional voiding and to obtain uroflowmetry and post-void residual measurements. Urodynamic studies may also prove useful in this regard for patients with unclear voiding dysfunction. High-pressure, low-flow voiding typical of obstructive

uropathy are often seen in patients with significant strictures (Fig. 24.1). Urinalysis and urine culture are also important to assess in order to rule out co-morbid neoplasms or infection.

Further laboratory tests such as a prostate-specific antigen test to assess for cancer recurrence or assessment of renal function may also be warranted [12].

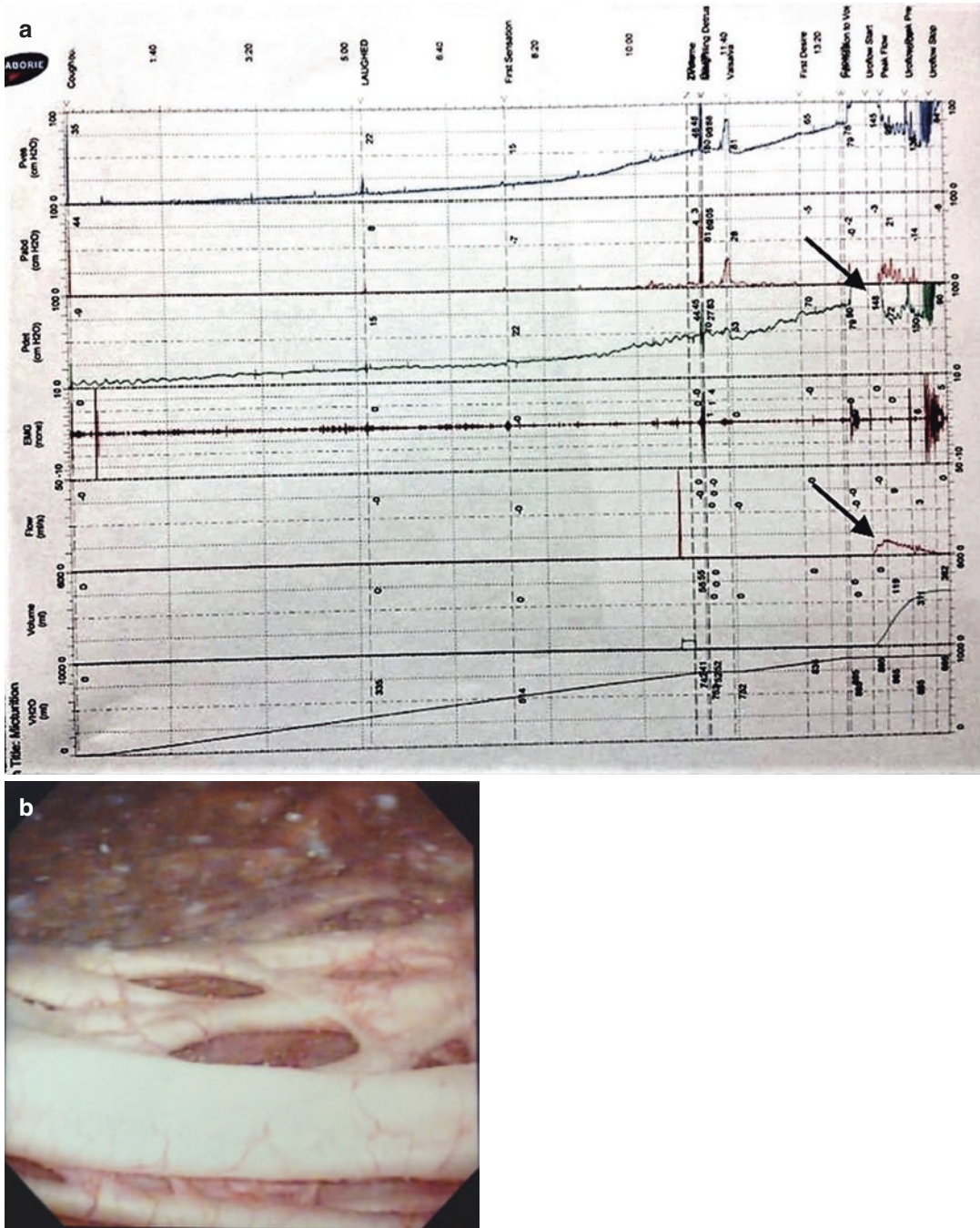


Fig. 24.1 (a) Urodynamics done in a patient after the diagnosis of radiation stricture, demonstrating poor compliance, elevated resting pressure at capacity and high-

pressure, low flow voiding. (b) Severe bladder trabeculations and fibrotic changes at the bladder neck in a patient with a history of prostatic radiation therapy

If a urethral stricture is suspected on the initial evaluation, cystourethroscopy should be performed next. Direct visualization of the stricture, assessment of its proximity to surrounding anatomic structures, as well as surveillance for other lower urinary tract pathology is of the utmost utility in assessing candidacy for surgical intervention (Fig. 24.2). In addition, urethroscopy is very useful for assessment of the quality of urethral tissue

(i.e. pink or pale urethral mucosa, mobile or fixed urethra, rigid or distensible lumen). Presence of calcifications, necrotic tissue and proximity to the urinary sphincter should be assessed.

Often, strictures present an obstacle to a retrograde scope passage. As a result, the number or length of strictures may not be readily assessed. Therefore, imaging is always indicated to assess the precise location and the burden of stricture

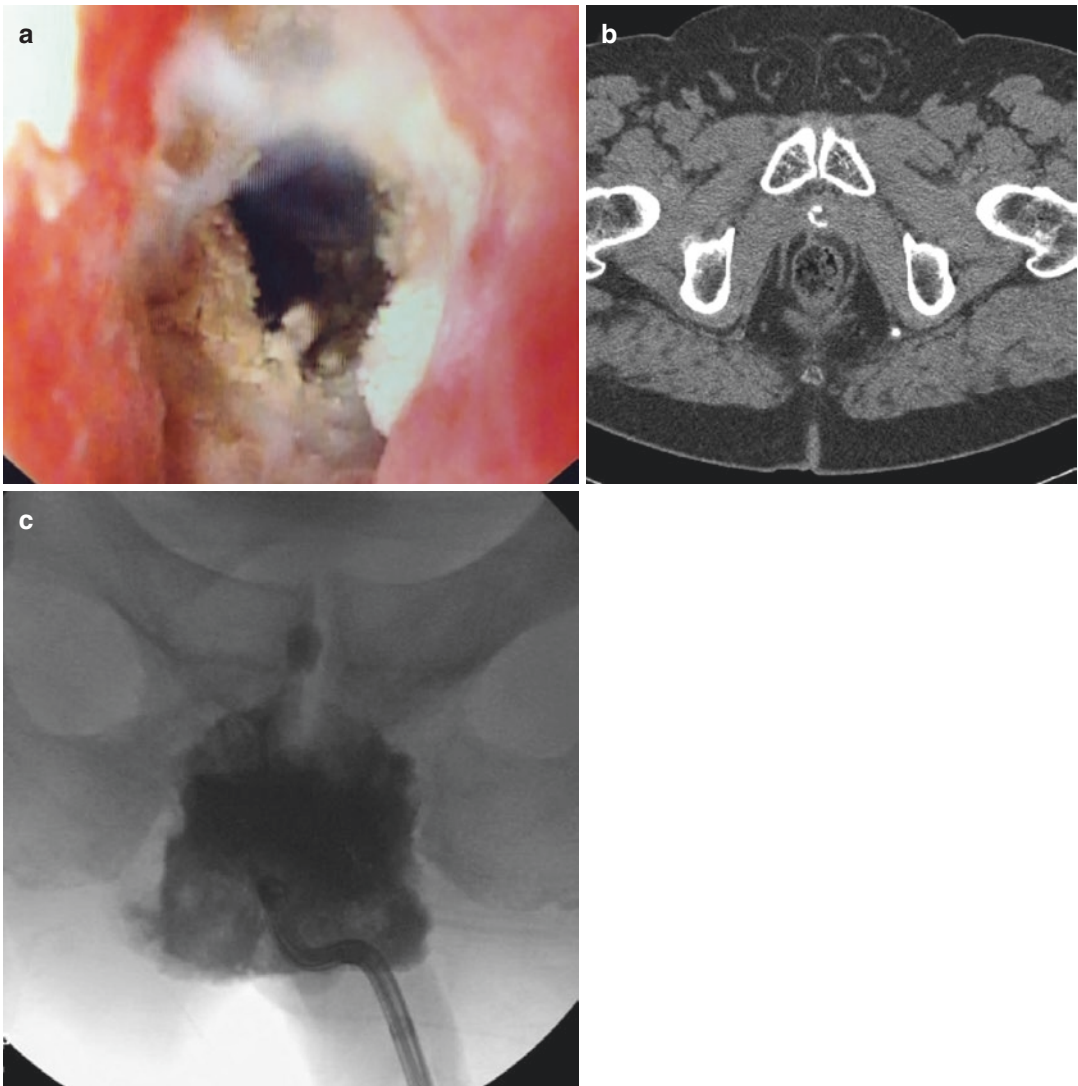


Fig. 24.2 (a) Fibrotic and necrotic bulbo-membranous tissue with calcifications caused by radiation. (b) CT scan from the same patient demonstrating calcifications in the necrotic segment of urethra. (c) Retrograde urethrogram

in an irradiated patient demonstrating a necrotic cavity, which is prohibitive to reconstruction and may be missed without imaging if necrotic tissue is visible on urethroscopy

disease. Retrograde urethrogram (RUG) combined with voiding cystourethrogram (VCUG) are generally well-tolerated studies which offer good visualization of the urethra and delineate proximal and distal limits of the disease. These studies can be performed with minimal radiation exposure and can be done in the office (Fig. 24.3). In select cases, particularly those with concern for obstructive uropathy causing upper-tract insult and in those patients with a suspicion for a urethra-symphyseal fistula, the inclusion of CT or MRI is indicated.

24.5 Therapeutic Options for the Management of Radiation-Induced Membranous Urethral Stricture

Current options for management of posterior urethral stricture include conservative techniques such as dilations or incisions [17–19], clean intermittent catheterization, or placement of an indwelling foley catheter or suprapubic tube. Beyond these, the primary reconstructive options

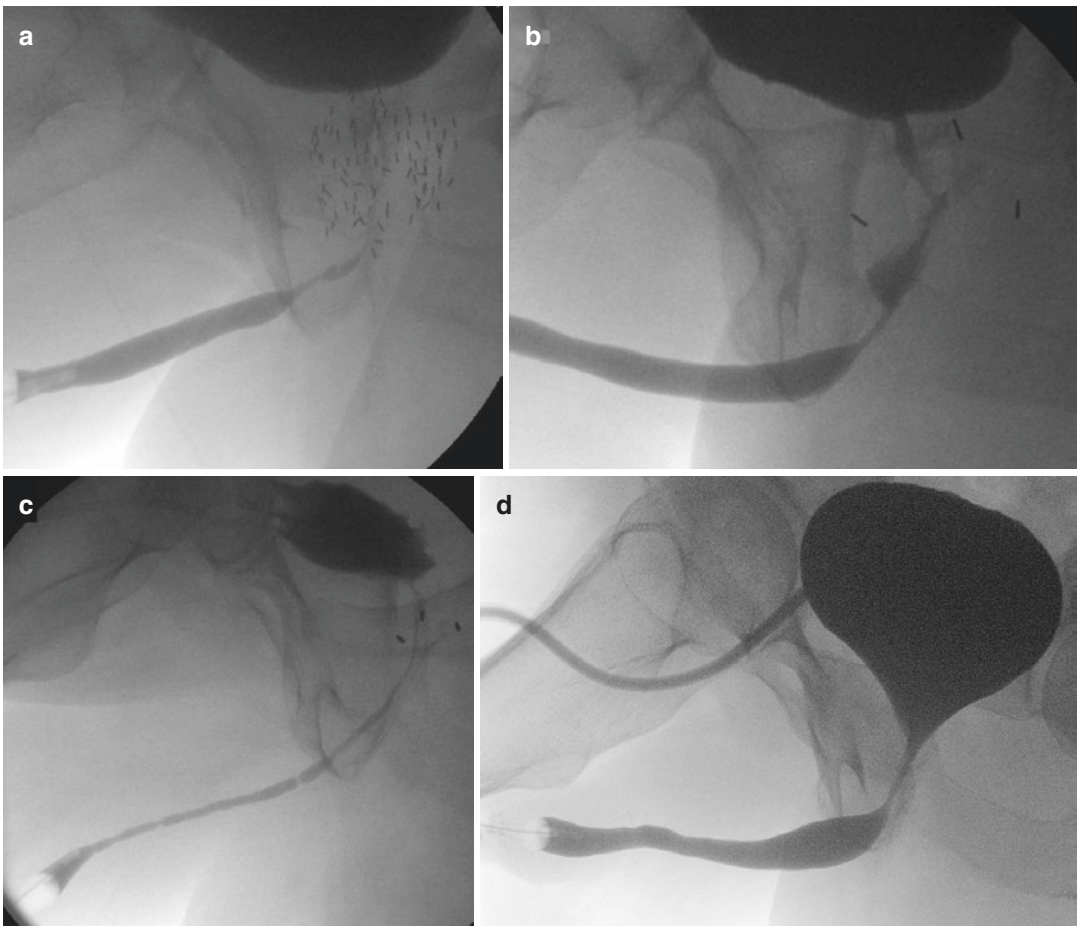


Fig. 24.3 (a) Bulbomembranous stricture visualized on combination retrograde urethrogram and voiding cystourethrogram in a patient with visible brachytherapy seeds. (b) Bulbomembranous stricture demonstrated on combination retrograde urethrogram and voiding cystourethrogram in a patient following EBRT with visible fiduciary markers. (c) Pan-urethral stricture demonstrated

on combination retrograde urethrogram and voiding cystourethrogram with visible fiduciary markers in a patient following EBRT. (d) Vesicourethral anastomotic stricture demonstrated on combination retrograde urethrogram and voiding cystourethrogram in a patient following prostatectomy and radiotherapy

that exist for management of post-radiation posterior urethral strictures include excision and primary anastomoses (EPA) or various forms of augmentation urethroplasty, such as buccal mucosal graft (BMG) onlay techniques. In particular cases of low functional status, co-morbid lower urinary tract conditions or refractory stricture recurrence, urinary diversion may also be appropriate, though it is not without risk [20].

Patient counseling and joint decision making is important in the process of care planning for post-radiation strictures. Often, these patients are of advancing age and varying functional status. Many factors should be considered when discussing management including oncologic status, performance status, surrounding tissue quality (degree of fibrosis, necrosis, calcification), stricture location/length/number, bladder status (capacity, compliance), current level of continence, and of course, patient preference.

24.5.1 Endoscopic Management of Radiation-Induced Strictures

Initial surgical management of stricture disease may consist of endoscopic treatments, such as dilation or incision of strictures or resection of the irradiated prostatic tissue. Additionally, concomitant injections of fibrosis-inhibiting agents have been suggested to assist in maintaining urethral patency after endoscopic intervention, though these have not been reported specifically in radiation stricture literature.

Dilation or direct-vision internal urethrotomy (DVIU) as an initial intervention has demonstrated limited success in the management of radiation-induced urethral strictures. In a 2006 retrospective review, Merrick et al. reported on independent predictors of stricture occurrence, finding that the total dose of urethral radiation, length of follow-up, higher pre-treatment PSA and use of supplemental radiation therapy were found to predict stricture occurrence. In their study, 9/29 (31%) patients with radiation induced stricture disease required multiple interventions to achieve patency, with 3 of the patients ultimately resorting to suprapubic tube placement as permanent man-

agement after failure [7]. Sullivan et al. focused on this trend in more detail in a 2009 retrospective review. The authors reported on a cohort of 35 patients with radiated bulbomembranous strictures that underwent DVIU or dilations and within a median follow up of 16 months, 17 patients (49%) required one or more repeated interventions. The investigators also noted a significant risk of de-novo incontinence in this patient population of 4/35, or approximately 11% [6].

Radiation induced bladder neck contractures also tend to fail incisional techniques as well [21]. Brede et al. examined a group of post-prostatectomy patients in 2014 and found that despite all of their patients having had at least 1 prior treatment for bladder neck contracture, those who failed repeated interventions were much more likely to have a history of radiation (75% vs 26%) [22]. Overall, the utility of repeated failed dilations or endoscopic incisions for radiation-induced strictures may relegate these methods to use in patients who are averse to more invasive procedures or those who cannot tolerate general anesthesia.

The prostatic urethra may form a circumferential fibrotic obstruction in a fashion similar to the bulbomembranous urethra and as such, prostatic radiation necrosis and fibrosis can also lead to lower urinary tract obstruction. Initially reported by Kollmeier et al. in 2005, a channel transurethral resection of prostate (TURP) for post-radiation prostatic obstruction required multiple procedures in 13% (5/38) of patients and caused de-novo incontinence in 7/38, approximately 18% of patients [23]. A large retrospective review by Abelson et al. of 6100 prostate cancer patients who underwent BT or EBRT demonstrated that 1.7% of BT patients and 1.1% of EBRT patients required subsequent prostate reduction surgery (TURP or Photovaporization) [8]. The authors also found that 49% of BT patients and 36% of EBRT patients failed these treatments and required further intervention. A significant rate of de-novo incontinence (36%) was demonstrated in these patients. Ultimately, while, some efficacy of transurethral resection of necrotic and fibrotic urethral tissue after radiation has been suggested by these studies, incontinence was a frequent complication and further interventions were often required (Table 24.1).

Table 24.1 Endoscopic management of posterior urethral obstruction after radiation

Author	N (Number patients)	Mean Age (years)	Etiology	Approach	Failures	De-novo incontinence	Follow up (months)
Kollmeier et al. [23]	38	65	EBRT, BT	TURP	13%	18%	38
Merrick et al. [7]	29	65	EBRT, BT	Dilation DVIU	31%	NR	89
Sullivan et al. [6]	35	66	EBRT, BT	Dilation 15 DVIU 20	49%	10.5%	16
Brede et al. [22] ^a	17	66	EBRT, BT	BNI	25%	NR	11
Abelson et al. [8]	88	67–70	EBRT, BT	TURP 58, PVP 30	44%	36%	44–49
Farrell et al. [27]	11	59	EBRT, BT	DVIU/BNI and MMC injection	45%	NR	28
Kamal Nagpal et al. [26]	9	64	Unspecified radiation	BNI and MMC injection	33%	NR for radiation subset	20.5
Redshaw et al. [28]	14	64	Unspecified radiation	BNI and MMC injection	36%	NR for radiation subset	9.2

^aAll patients had previously failed at least 1 endoscopic intervention for BNC

Though adjuvant injection of anti-fibrotic agents has been sparingly evaluated in radiation strictures, dissatisfaction with current recurrence rates after endoscopic procedures in all-cause stricture disease has given rise to adjunctive use of injected substances designed to prevent urethral re-stenosis by inhibiting the process of fibrosis. In two series evaluating treatments of post-prostatectomy bladder neck contractures, adjunctive steroid injections were given at the time of dilation, DVIU, or trans-urethral resection of the stenosis, and appeared to provide improved outcomes [24, 25]. Elthawy et al. reported on a series of 24 patients with previous prostatectomy who underwent laser bladder neck incision and steroid injection and found that after either one or two sessions, satisfactory patency was achieved in 83% of the study cohort [24]. However, of the 5 patients in the study who had a history of radiation, 1 was recalcitrant to this treatment and required suprapubic tube placement.

Mitomycin C has also demonstrated some efficacy in a similar application. Nagpal et al. have reported a 75% success rate of a single DVIU and MMC injection in a series of 40 patients without any significant complications at a mean of 20.5 months follow up [26]. However, a 33% failure rate after a single treatment was noted in the subset (3/9) of previously radiated patients.

Farrell et al. reported a prospective case series of 37 patients who underwent DVIU combined with Mitomycin C injections and found that in their subset of 11 radiation-induced strictures, DVIU and MMC injection was only noted to be 55% successful, compared to 85% success in non-radiated strictures [27]. Of note, an important caveat is seen in data from a series of 66 patients by Redshaw et al., which warns of a 7% risk of severe adverse events including osteitis pubis in two patients, severe bladder neck necrosis in one and severe necrosis and rectourethral fistula formation in another after MMC use for endoscopic stricture management. They also report a 36% recurrence rate at 3.7 months, regardless of a history of radiation [28]. Ultimately, the results of MMC injection to augment endoscopic management of urethral strictures are currently mixed. Repeated interventions are often required to achieve success, and significant complications have been reported. Human Placental Tissue Allograft (AmnioFix) use as an adjunctive injectable agent has also begun to draw interest recently, although clinical data is currently lacking and the most reliable data at this point remains in animal studies [29]. Overall, adjuvant injection of anti-fibrotic agents will require larger studies before conclusions can be safely drawn

and there is no data on their utility in radiation induced strictures specifically.

24.6 Reconstructive Techniques

24.6.1 Excision and Primary Anastomosis

Prior to the standardization of bulboprostatic anastomosis techniques [30–32], historical studies have described very aggressive or convoluted solutions, which are now very rarely required to treat membranous urethral stricture. Such procedures included combined abdomino-perineal transpubic exposure achieved by total pubectomy [33, 34], perineal approach with skin-tube substitution [35], or a two-stage urethroplasty with scrotal skin inlay [36, 37].

Single-stage urethroplasty done through a perineal approach for strictures <2.5 cm in length due to posterior disruption was popularized in the 70s [38]. In the early 90s, a perineal approach involving progressive steps to allow tension-free anastomoses was introduced for treating defects as long as 7 cm [39]. An abdomino-perineal approach is occasionally used, but this should be reserved for cases in which there is a large (6–9 cm) defect in the membranous and prostatic urethra, as well as severe injury to the bladder neck requiring reconstruction. More recently, to avoid an open abdominal approach, Sun et al. proposed a robotic approach to radiation-induced stenosis [40]. In their case series, 4 patients were treated with a robotic-assisted abdominal approach in combination with fluorescent light technology to identify the level of stenosis during the operation. This robotic-assisted approach has promising initial patency outcomes at a median follow-up of 4 months, although the authors have not reported on continence outcomes.

The approach for EPA is via the classical perineal access used for reconstruction of the membranous urethra. This approach begins with central tendon dissection to expose the prostatic apex and lysis of any scar tissue surrounding the stricture. The posterior urethra is dissected totally and mobilized. In the treatment of radiated strictures, this step is often more difficult and time consuming. In order to better identify the proxi-

mal end of the stricture, it is often very helpful to insert a curved metal probe suprapubically or a flexible cystoscope through an Amplatz sheath. In order to prepare the proximal side of the anastomosis with 8–12 sutures, a long nasal speculum or a grooved gorget is used to spread open the prostatic apex. Next an absorbable suture is placed using a bent-open curved needle, inserted lengthwise to piercing the apex and mucosal tissue from the outside in. Using the same needle driver, the tip of the needle is recovered by pushing in and out of the bladder. The distal urethral stump is then spatulated to fit the size of prostatic apex. In order to shorten the length of the gap for the anastomosis, the corpora cavernosa can be split in the midline, thus allowing a more direct passage for the mobilized urethra. If further mobilization is required, cural separation exposes the inferior pubic symphysis, where dorsal vein ligation and pubic bone wedge resection allows additional gap shortening. If traversing of an additional 1–2 cm is required, the mobilized urethra may be re-routed via dissection of the corporeal body on one side and passage of the urethra around it on the groove made by the inferior pubectomy. A conversion to a combined abdomino-perineal approach is required if total pubectomy is needed. Ultimately, if all else fails, a tailored, interposed flap of sigmoid colon may serve as another resource for unsalvageable bulbo-membranous strictures [41].

With success defined as the lack of need for additional procedures, large series of bulboprostatic anastomoses for non-irradiated strictures demonstrate a 86–93% success rate [42–47]. In radiation stricture patients, success rates of 65–95% are reported [48–53] with only one small early series of 3 patients by Elliot et al. demonstrating a 100% success rate [54]. The largest retrospective series by Fuchs et al. described outcomes of EPA in treatment of 72 radiation stricture patients and reported success rate of 76% at a mean follow up of 36 months [51]. Hofer et al. reported similar success rates in the second largest series reported, with 20/66 (30%) of patients developing recurrent strictures [49]. Two smaller series of 35 patients by Rourke et al. and 27 patients by Glass et al. report a 91–95% patency rate of EPA for radiation strictures at 40–50 month

follow up compared to 75–80% success for augmentation-type urethroplasties [50, 53]. However, in these studies, EPA was offered to patients with shorter strictures compared to those treated with substitution techniques (mean 2.1 cm vs 6.1 cm, respectively). Specifically, in the larger of the two series, those undergoing BMG urethroplasty were not separated from those requiring a fasciocutaneous flap. This type of selection bias is often present in retrospective studies, which relegate augmentation urethroplasty to those with longer strictures and combine cohorts treated by various techniques (Table 24.2). Therefore, one should be careful and not be tempted to make conclusions or comparisons between the reported success rates of various techniques or to try to determine superiority of one technique over another based on these data.

Most of the earlier series on bulboprostatic EPA repairs did not report continence outcomes. In studies that did investigate new-onset post-

operative stress incontinence for anastomotic urethroplasties, it has been reported as high as 12–37% [55, 56]. In radiation stricture patients, de-novo urinary incontinence after EPA can be as high as 36% with 13–17% requiring a delayed placement of an artificial urinary sphincter (AUS) [48–50, 56]. In a study aimed specifically at evaluating incontinence rates, Chung et al. report on the continence rate of a retrospective series of 36 successful EPA urethroplasties for radiation-induced strictures. The authors found a 33% de-novo stress incontinence rate in these patients [56]. In the same study, the population of radiated patients was compared to a control cohort of patients with pelvic fracture urethral disruption injury who underwent the same type of posterior urethroplasty. In contrast, only 12% incontinence was noted in the control group, suggesting that radiation itself may be a risk factor for de-novo incontinence either due the generation of more proximal strictures, or due to intrinsic damage

Table 24.2 Posterior radiation stricture urethroplasty

Author	N (Number patients)	Mean age (years)	Etiology	Approach (#)	EPA failures	Augmentation failures	De Novo incontinence	Follow up (months)
Elliott et al. [54]	3	71	EBRT, BT	EPA	0 (0%)	NA	NR	NR
Lumen and Oosterlinck [52]	3	70	EBRT, BT	EPA	1 (33%)	NA	33%	32
Meeks et al. [48] ^a	30	67	EBRT, BT	EPA (25) Flap (3) BMG (2)	8 (27%)	1 (20%)	40%	21
Glass et al. [53] ^a	27	69	EBRT, BT	EPA (22) BMG (5) Flap (2)	1 (5%)	1 BMG (20%) 1 Flap (50%)	7%	40
Hofer et al. [49] ^a	72	NR	EBRT, BT	EPA (66) BMG (4) Flap (2)	20 (30%)	1 (17%)	36% EPA 50% Augment	42
Ahyai et al. [74]	38	69	EBRT, BT	Ventral BMG	NA	11 (29%)	10.5%	26
Blakely et al. [68]	3	48	EBRT	Dorsal BMG	NA	0 (0%)	0 (0%)	8
Rourke et al. [50] ^a	35	68	EBRT, BT	EPA (23) BMG (7) Flap (5)	2 (9%)	3 (25%)	26% EPA 25% Augment	50
Fuchs et al. [51]	72	71	EBRT, BT	EPA	17 (24%)	NA	35%	36
Chung et al. [56]	36	69	EBRT, BT	EPA	NR	NA	33%	18

^aInvestigators used augmentation only in cases where excessive stricture length prohibited EPA

to the bladder neck. Thus, surgeons should thoroughly counsel their patients about the increased risk of urinary incontinence after urethroplasty for radiation induced stricture disease.

Erectile dysfunction is another important topic requiring in-depth discussion prior to urethroplasty. When dismembering the bulb of the penis during EPA, the cavernous nerves and vessels are often in harm's way, yet there is a paucity of studies reporting on the sexual outcomes after urethroplasty. In non-radiation strictures, postoperative erectile dysfunction after urethral reconstruction ranges between 25–53%, but is confounded by the status of preoperative erectile function, ultimately reaching *de novo* rates of 3–7% [57]. In radiation stricture patients, *de novo* erectile dysfunction has been reported to reach 3–35% of patients undergoing EPA [48–50]. Rourke's 2016 series noted an adverse effect on erectile function in 35% of EPA patients, compared to 0% of their BMG onlay repairs, which were used for longer strictures [50].

It is also worth noting that intra-sphincter bulboprostatic anastomotic techniques may offer improved outcomes when compared to traditional EPA. Urethral mobilization for bulbo-prostatic EPA sacrifices the bulbar arteries with few apparent side effects, however it is thought that preservation of the proximal blood supply may reduce the risk of ischemic erosion patients who may desire AUS placement [58]. This approach utilizes the dissection of a plane delineated by a delicate sheath of connective tissue between the wall of the membranous urethra and the surrounding circular fibers of the external sphincter. When attempting this type of dissection in a radiation stricture patient, complicating local fibrosis can be anticipated. This approach allows the preservation of the anterior divisions of the cavernous bundles as they cross the bulb of the penis by allowing dissection within the bulb, as opposed to outside of it, before its separation from the urogenital diaphragm [59, 60]. The bulbar artery sparing approach solidified by Jordan is reproducible with success rates of 95–100% [61, 62], however the body of experience with this technique is still lacking. In radiation stricture patients, this technique may prove even more difficult, yet if it can be safely achieved, then preservation of proxi-

mal blood supply would likely benefit healing in tissue that is already devascularized by radiation insult. This however, is a hypothesis that is not yet validated in the literature.

24.6.2 Buccal Mucosa Graft Urethroplasty

Patch urethroplasty has been used comparatively less often than bulboprostatic anastomosis for the management of membranous urethral stricture, likely due to the refinement and popularization of the Turner-Warwick step-wise approach to posterior urethroplasty by Webster and the difficulty involved in tailoring and quilting graft tissue [36, 39]. For decades however, open "stricturotomy" and repair with a penile or scrotal skin flap or free graft has also been widely used as an alternative to bulboprostatic anastomosis [55]. Patch-graft urethroplasty was first described in the membranous urethra in 1976 using a penile skin graft onlay placed ventrally in a series of 38 patients, and was found to have an 82% success rate [63].

Today, most urethral plate preserving bulbar urethroplasties are performed with a buccal mucosa graft placed ventrally or dorsally, as buccal mucosal urethroplasty is a versatile technique for all urethral segments [64]. Ventral bulbar augmentation for proximal bulbar stricture was described in 2010 [65]. Barbagli et al. have used this ventral onlay approach in a large series of various non-traumatic stricture etiologies including those with large proximal bulbo-membranous urethral strictures (median 4.4 cm length). This method of ventral urethrotomy was performed via insertion of a nasal speculum into the proximal opening, with incision of the urethral mucosa up to the verumontanum. Three stitches at 5, 6 & 7 o'clock were placed with a J-shaped needle in order to fix the BMG proximally [66]. In cases where the urethral plate was too narrow, the margin of the graft was sutured to the adjacent corpus spongiosum. This technique had a success rate of 85.5% at 54 month follow-up [67]. The etiology of the stricture, length of the stricture and thickness of the urethral plate were not found to be predictive factors for success (Fig. 24.4).

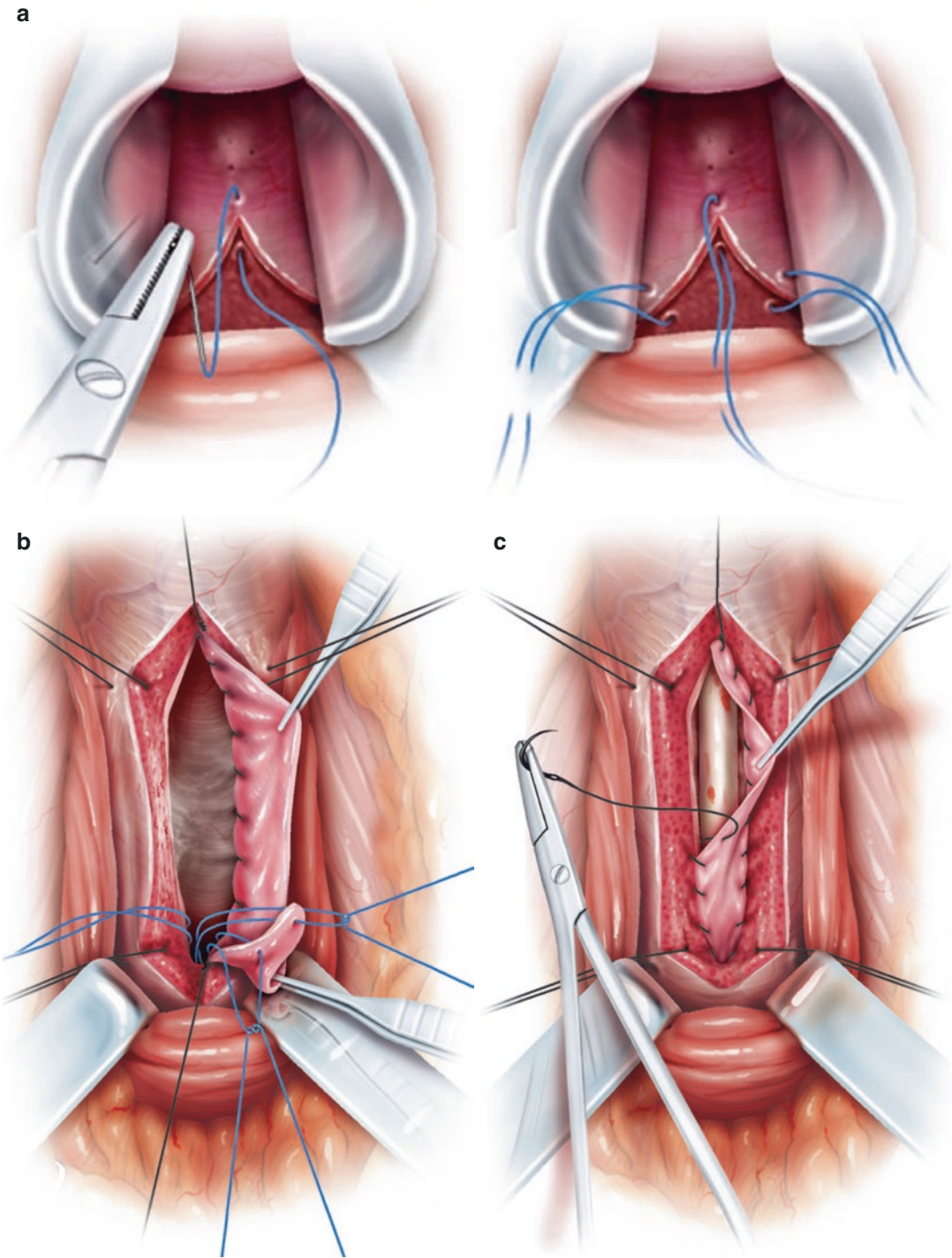


Fig. 24.4 Ventral onlay urethroplasty. (a) Demonstration of J-shaped needle placement. (b) Anastomosis of the BMG graft to the left edge of the ventral urethrotomy. (c) Completion of BMG anastomosis to the contralateral urethral edge over foley catheter. (a, b, c: Courtesy of

G. Barbagli, 2011). (d) Intra-op visualization of ventral onlay exposure. (e) Intra-op visualization of anastomosis of the BMG graft to the left edge of the ventral urethrotomy. (f) Intra-op visualization of ventral onlay BMG anastomosed in place. (d, e, f: Courtesy of D. Nikolavsky)

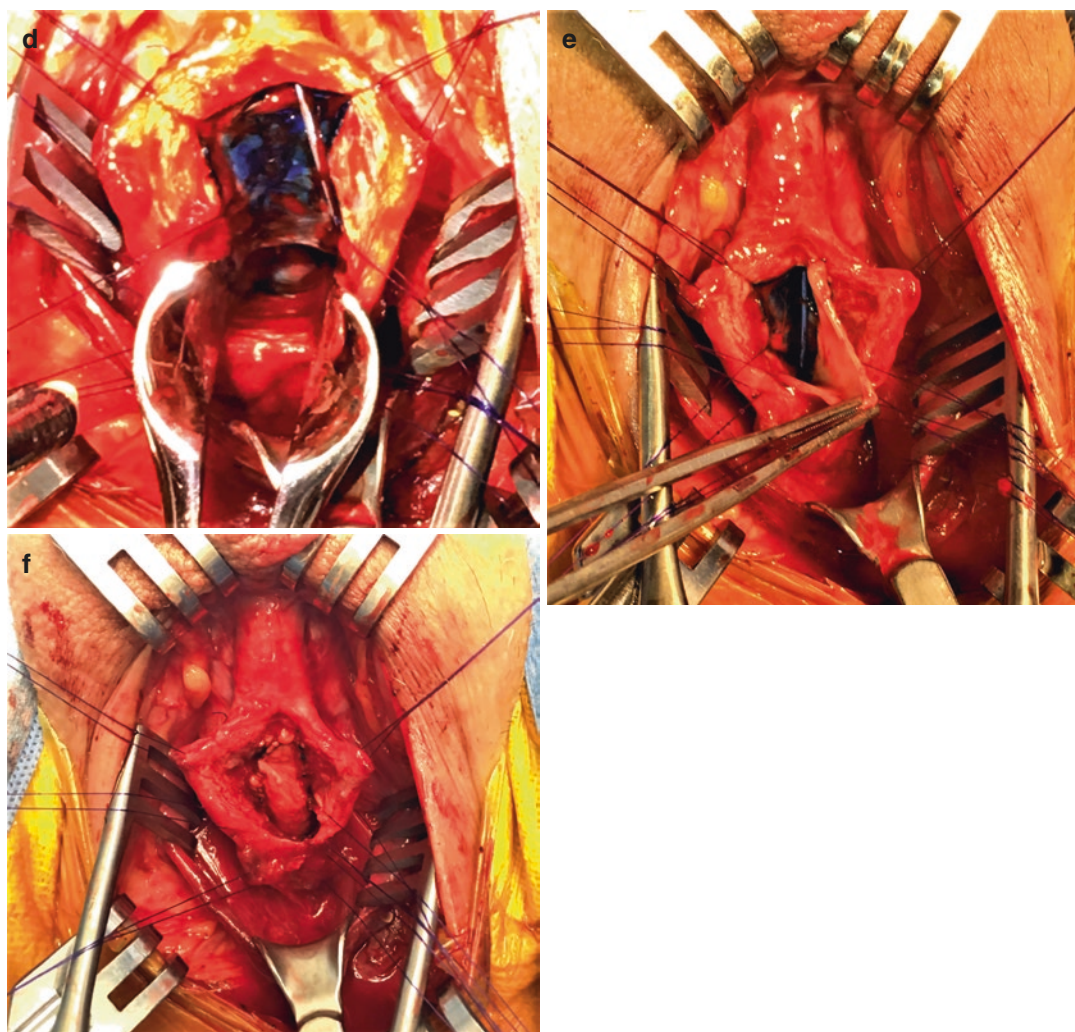


Fig. 24.4 (continued)

Compared to other currently available techniques for augmentation urethroplasty of membranous urethral strictures, dorsal onlay urethroplasty is likely the option that best preserves the natural anatomy of the posterior urethra and seems to provide excellent sexual and continence outcomes. Dissection of the posterior urethra can be performed dorsolaterally either on one side [68] or dorsal bilaterally [69], with preservation of the urethral continuity, sparing of bulbar vessels and bulbospongiosus muscle. After a careful urethral dissection and lateral rotation the space between the diverging crura is then carefully exposed. Similarly, to an intrasphincter bulboprostatic anastomosis, dissec-

tion must be done carefully in order to spare the striated muscle of the rhabdosphincter and the cavernous nerves, which is more challenging in radiated patients. This approach allows for preservation of the U-shaped cavernous nerve mesh attached to the lateral and posterior aspects of the rhabdosphincter [70]. The dorsal aspect of the urethra is then incised longitudinally through the length of the stricture, with extension approximately 1 cm proximal and distal into normal urethra. Passage of a 4–5 French urethral catheter or a guidewire prior to initiating the procedure can assist in exposing the membranous urethra neatly, by allowing a sharp incision along the guide. No cautery should be used in the prox-

imity of the membranous urethra and cavernous nerve mesh. Resection of the peri-urethral scar tissue must be limited to the area between the 11 and 1 o'clock positions which allows preservation of the omega-shaped rhabdosphincter. At this point, the lumen is widely exposed and three stitches are passed outside-in, through the proximal end of the urethrotomy, at the 11, 12 &

1 o'clock positions to fix the proximal BMG in place. An appropriately sized oral graft is then harvested and secured to the apices of the urethrotomy with the pre-placed sutures. Quilting sutures are then used in order to fix the graft to the corpora cavernosa and the intercrural space [68, 69]. The main steps of this procedure are demonstrated in Fig. 24.5.

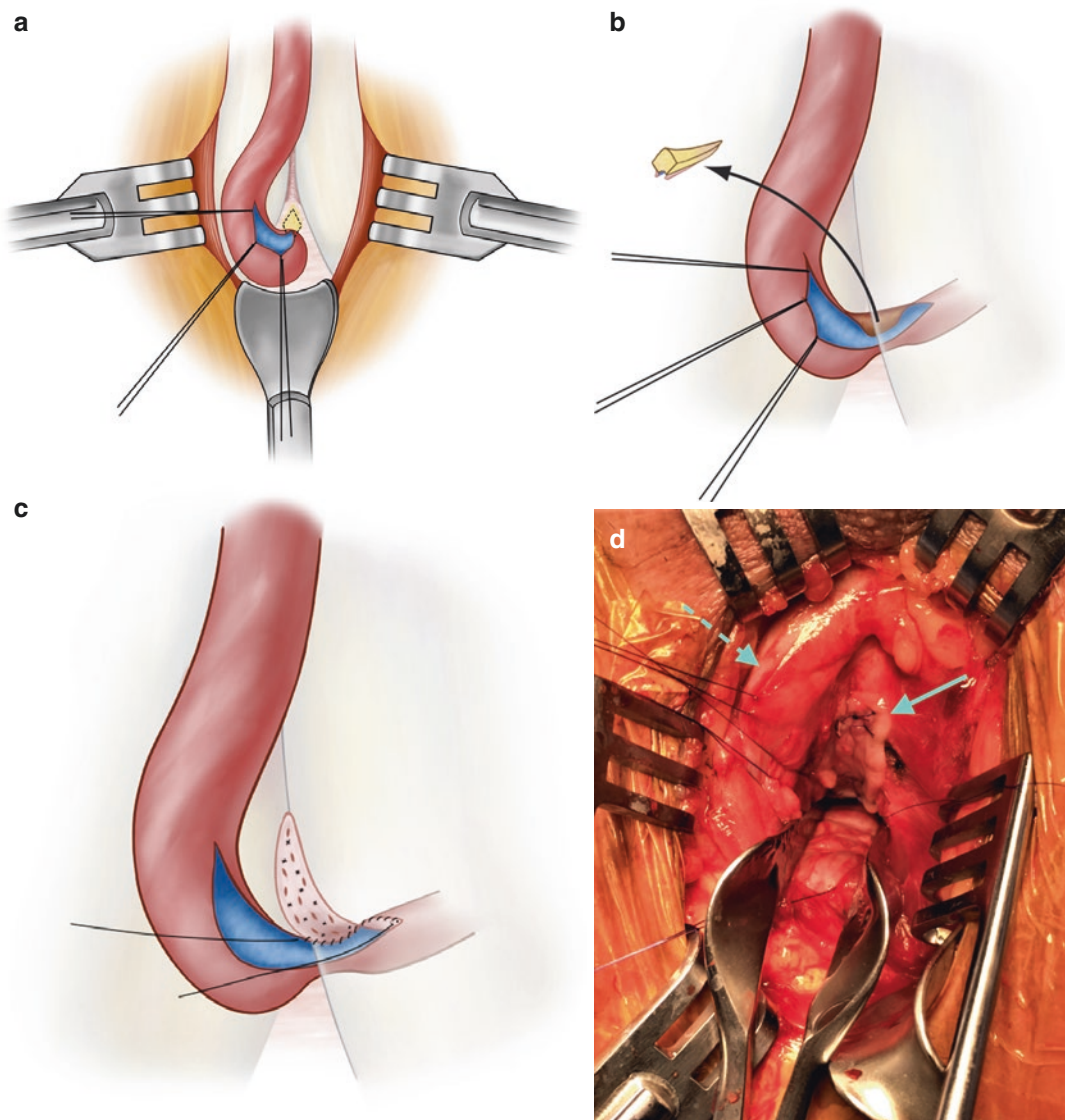


Fig. 24.5 Dorsal onlay urethroplasty. (Courtesy of S. Blakely, 2016). (a) lateral dissection of urethra and dorsal urethrotomy. Dotted line indicates area to be excised. (b) intercrural tissue is excised anterior between 1 and 11-o'clock positions. (c) buccal mucosa is sutured to proximal apex of urethrotomy and quilted on corpora caver-

nosa. (d) intraoperative image shows repair of a bulbomembranous urethral stricture. Bulbar urethra with dorsal urethrotomy is rotated toward patient right (dashed arrow). Elliptical buccal mucosal graft (solid arrow) is quilted to underlying corpora cavernosa. Nasal speculum is placed in bladder through proximal urethral lumen

Assuming that excision of the fibrosis allows sufficient residual plate, the membranous urethra is also amenable to a non-transecting approach, utilizing a wide mucosal graft. The use of a wide bulbo-membranous graft confers several benefits: it counteracts the less compliant nature of the native membranous urethra; helps to avoid urethral shortening; helps avoid perilous circumferential urethral dissection with regard to the cavernous nerve bundles and impairment of urethral vascularization; and avoids the risk of chordee development in the pendulous urethra due to excessive urethral dissection [69]. It is worth noting that dorsal and ventral onlay BMGs have comparable efficacy and complication rates when it comes to treatment of all-cause long-segment bulbar urethral strictures [71].

Based on these observations, urethroplasty with BMG seems advantageous when compared to EPA in the bulboprostatic urethra for longer strictures [72]. Currently, no comparative trial addresses this particular issue, however a recent meta-analysis comparing end-to-end anastomosis and buccal mucosal graft in bulbar stenosis demonstrated equivalent effectiveness and low complication rates for both techniques, but also noted the superiority of buccal mucosa graft in terms of effects on sexual function [73]. Numerous institutions have begun reporting data in favor of a non-transecting and non-shortening approach in long bulbar strictures with membranous involvement [67–69, 74].

With regard to post-radiation strictures, BMG augmentation urethroplasties have been shown to provide similar results to anastomotic urethroplasty in these difficult cases. Patency rates have been reported from 71–75% and as high as 100% in one small series [50, 68, 74]. In the majority of the current studies, augmentation urethroplasty with the use of either a graft or flap were only used in patients who were thought to have strictures too long for EPA. The largest experience with BMG onlay for radiation strictures comes from Ahyai et al. in who have reported on the experience with 38 patients who underwent a ventral onlay BMG urethroplasty. In this series, the overall success rate was 71% at a mean follow-up of 26.5 months [74]. Blakely et al. reported on a small series of 3 radiated patients among 16 patients with

membranous urethral strictures who underwent dorsal onlay BMG urethroplasty [68]. Of these patients, all were found to remain patent, with no de-novo incontinence at 8 months of follow up. The remaining series reporting augmentation urethroplasty with BMG graft relegated these repairs to strictures felt to be too long for EPA. As a result, the literature specifically evaluating BMG onlay urethroplasty in irradiated patients is limited.

Literature evaluating functional urinary and erectile outcomes of BMG onlay urethroplasty for all-cause membranous urethral strictures remains scarce as well. Some evidence demonstrates that despite 50–65% of a patient population having had a previous TURP or radiation therapy, continence was not affected [68, 69]. In radiation stricture patients, Ahyai et al. noted a 10.5% de novo urinary incontinence rate following ventral onlay BMG urethroplasty [74]. Two studies reported higher rates of de-novo incontinence, reaching 25–50% [49, 50]. However, in these studies the cohorts were small (6–12 patients) and those undergoing BMG urethroplasty were not separated from those requiring fasciocutaneous flaps when reporting outcomes [49, 50] (Table 24.2) Reconstruction using dorsal BMG after radiation has also not been associated with adverse changes in erectile function that are typically characteristic of anastomotic urethroplasty, with three of four studies reporting no de-novo erectile dysfunction in BMG urethroplasty patients [49, 50, 68]. However, the largest series of BMG urethroplasties in radiated patients by Ahyai et al. does report a 6.3% de novo erectile dysfunction rate using a ventral onlay approach [74]. This decreased risk of de novo erectile dysfunction may represent a significant benefit provided by augmentation urethroplasty.

Ultimately, series reporting BMG urethroplasty in radiated stricture disease are small in sample size when compared to EPA literature and often confounded by selection bias, as many retrospective analyses only perform augmentation urethroplasties on patient with stricture though to be too long for EPA. Further comparative data regarding recurrence, continence and erectile function assessed by patient-reported outcome measures are required to determine whether membranous urethroplasty with BMG is truly

advantageous over EPA in the management of radiation-induced stricture disease.

24.6.3 Management of Radiation-Induced Lower Urinary Outlet Obliteration

Though little data is currently reported for management of complete urethral obliteration due to radiation therapy aside from the results of EPA, some recent work is emerging that appears promising. A case series of 20 patients reporting the use of a version of the Solavov-Badenoch urethral pull-through technique and staged AUS placement for this indication was recently reported in a published abstract. The technique involves urethral mobilization, creating a wide tunnel through the scarred area and a pull-through of the distal urethral stump across the created tunnel. The authors have reported a stricture recurrence rate of 20%, and an 85% “social continence” rate at a median follow-up of 22 months [75, 76].

24.6.4 Devastated Outlet: Terminal Bladder, Necrotic Cavity

As patients fitting this particular subset are infrequent, further work specifically evaluating reconstructive options for a devastated outlet will likely require multi-institutional protocols. Bassett and colleagues evaluated 100 men from nine different institutions who underwent urinary diversion for management of severe urinary adverse events, including strictures, fistulas, and necrosis of the bladder, urethra or prostate from radiation. While diversion is often a last resort, this study demonstrated that 36% of patients undergoing diversion for this indication had significant perioperative complications, defined as Clavien grade 3a or greater, with 19.5% of patients having a complication of Clavien grade 4 or above [20].

24.7 Conclusion

Literature regarding the management of membranous (or sphincteric) strictures is relatively

scarce, especially in cases of radiation-induced disease. Novel and interesting techniques appear to be developing in order to address this difficult cohort of patients, such as adjuvant intra-lesional injection of anti-fibrotic agents and combination EPA/BMG repairs. With regard to the two most common repair techniques, BMG urethroplasty has been used and reported on less frequently than excision and primary anastomotic techniques, but appears to be a promising alternative and may provide a lower risk of complications. Undoubtedly, the literature regarding the various surgical management techniques described in this chapter is continuing to evolve with new and promising techniques on the horizon.

Key Summary Points

- Radiation induced strictures are a fairly prevalent complication of prostatic radiation, with the highest rate occurring after brachytherapy.
- Evaluation and counseling of patients with radiation-induced strictures should be done with goals of care in mind and include a thorough discussion of the risks and benefits of the various treatment modalities available. Patients should be aware of the high risk of recurrence and de novo incontinence.
- Endoscopic management of radiation induced urethral stricture or prostatic necrosis causing obstruction have poor success rates, often requiring multiple interventions to achieve patency.
- Anastomotic and augmentation urethroplasty techniques are valid methods for management of radiation strictures, however initial results for augmentation urethroplasty demonstrate the possibility of preferable continence and erectile function outcomes.
- Larger, prospective studies of radiation-induced stricture management, including functional and patient-reported outcomes will be important in delineating the best standard of care moving forward.

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Surgical Reconstruction of Posterior Urethral Complications Following Prostate Cancer Treatments

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25.1 Introduction

Prostate cancer (PCa) is the most common non-cutaneous malignancy among men in the Western world [1]. Besides active surveillance, most common treatment options are radical prostatectomy (RP) and radiotherapy, including external beam radiation (EBRT) and brachytherapy. Novel treatment options are high-intensity focused ultrasound (HIFU) and cryoablation. Currently, more than 80% of patients with clinically localized PCa undergo definite treatment [2]. Along with the well-described treatment-related adverse events urinary incontinence and erectile dysfunction [3], bladder outlet obstruction (BOO) represents another common sequel. Other important complications following PCa treatment include urinary or rectal bleeding, infection of the urinary or lower gastrointestinal tract, and urorectal fistulae (URF) [4]. Given 90% overall and 99% cancer-specific survival at 10 years [5], a relevant proportion of patients is at risk of these complications. Treatment options in case of urinary incontinence and erectile dysfunction as well as treatment strategies of radiogenic urethral strictures will be dis-

cussed elsewhere in this textbook. Thus, the aim of this chapter is to delineate the epidemiology, etiology, diagnosis, preoperative evaluation, and treatment of BOO and URF following surgical or non-surgical PCa treatment.

Given recent initiatives to improve validity and comparability of urologic reconstructive research [6], we believe it is important to shortly underline that the term ‘urethral stricture’ should only be used if the urethra is surrounded by corpus spongiosum, which precludes the prostatic urethra. Thus, when referring to a narrowing of the prostatic urethra following radiotherapy the term ‘prostatic urethral stenosis’ should be used [6]. Furthermore, we believe it is inevitable to distinguish between a bladder neck stenosis after transurethral surgery for benign disease and vesico-urethral anastomotic stenosis (VUAS) after RP [6], given that etiology, anatomy, treatment success and incontinence rates are different [7]. Both, prostatic urethral stenosis and VUAS may be summarized as BOO and are labeled accordingly in this chapter. Considerations regarding the surgical reconstruction of the membranous urethra after radiotherapy are discussed in a separate chapter.

In the second part of this chapter we focus on the epidemiology, etiology, diagnosis, evaluation, and treatment options of URF. Surgical options for patients with incontinence are discussed elsewhere in this textbook.

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25.2 Bladder Outlet Obstruction

25.2.1 Epidemiology

When interpreting the available evidence on BOO following PCa treatment, it is important to underline that BOO is mostly defined as the need for an intervention based on a patient's complaint. We are not aware of a prospective study analyzing urethral patency via standardized diagnostic procedures after PCa treatment. In most studies, interventional or surgical procedures are considered the surrogate of BOO diagnosis. Thus, BOO prevalence is indeed likely to be underestimated. An analysis of the CaPSURE database published in 2007 gives some durable insight into epidemiology of BOO related to PCa treatment. At a mean follow-up of 2.7 years, overall obstruction rate among all treatment modalities was 5.2%. Highest prevalence of BOO with 8.4% was seen in patients treated with RP [8]. Of note, BOO rates in patients treated with RP and adjuvant radiotherapy were lower (2.7%). Other single institution data further reported a decline in BOO rates over the last years. Interestingly, the authors report slightly lower BOO rates of roughly 1.4% following robot-assisted laparoscopic RP compared to rates of up to 9% after open RP [9–11]. These data additionally suggest that besides the impact of improved surgical technique developed over time, rates of BOO for both robot-assisted laparoscopic and open RP are lower in experienced, high volume surgical hands. Using the same dataset, the incidence of BOO following cryotherapy is reported with 2.7% [8], and BOO rates after HIFU range between 1% and 31% [12]. Notably, BOO in patients treated with salvage RP after failed primary radiotherapy is significantly more common (22–40%), but evidence predominantly originates from small case series [13, 14]. Regarding focal therapy in the salvage setting, BOO rates range between 5% and 12% following salvage cryotherapy and between 15% and 30% following salvage HIFU [15–18]. It is important to note that beyond urethral obstruction, salvage therapies also inherit a much higher risk of both urinary incontinence and rectal injury with or without URF [19].

25.2.2 Etiology

25.2.2.1 Prostatic Urethral Stenosis

Radiotherapy relies on ionizing radiation. On the one hand, tumor cells are destroyed by reactive oxygen species [20]. On the other hand, radiotherapy induces collateral damage to the surrounding tissue by obliterating endarteritis. Both effects cause progressive fibrosis [20]. As this is an ongoing process, side effects such as urethral stricture formation after radiation for PCa often develop many years after therapy.

Cryotherapy causes direct cell damage by formation of ice crystals, by dehydration, by acidosis, and by vascular injury. Similarly, cellular swelling caused by osmotic processes and hyperpermeability contributes to cell damage in the warming phase, which eventually leads to coagulative necrosis [21].

HIFU relies on inertial cavitation generated by cycles of compression and rarefaction. This process causes mechanical stress to the targeted tissue resulting in coagulative necrosis [22].

In the prostatic, posterior urethra, stricture formation comparable to bulbomembranous strictures after radiotherapy is rare. However, 1–7% of patients require transurethral resection of the prostate (TURP) for chronic urinary retention after brachytherapy (Fig. 25.1). In about



Fig. 25.1 Prostatic urethral stenosis after low dose brachytherapy for prostate cancer. Retrograde urethrography shows almost complete radiogenic urethral obliteration. Seeds are still in place

3%, cases of chronic urinary retention have been reported after EBRT.

Further on, BOO can occur due to prostate necrosis leading to sloughing. Both radiotherapy and ablative therapies have been associated with this phenomenon [17, 23], usually very early after therapy. Persistent obstruction of the prostatic urethra is described mostly due to ongoing effects of radiotherapy [24].

25.2.2.2 Vesico-urethral Anastomotic Stenosis

As preoperative measurable risk factors, obesity, smoking, diabetes, and comorbidities such as hypertension are discussed to increase the risk of VUAS [25]. All of these factors may lead to impaired microvasculature, possibly preventing healing of the anastomosis. TURP prior to RP and a large gland are presumed risk factors of VUAS [25, 26]. During RP, extensive blood loss, mismatch of the bladder and urethral mucosa and high tension on the anastomosis seem to enhance the risk of a VUAS [12, 25]. Running sutures of the anastomosis as well as robot-assisted compared to open procedures are supposed to lower the risk of a VUAS [9, 27]. Generally, VUAS develops within the first 6 months after RP and rarely presents later than 2 years after surgery [8].

25.2.3 Diagnosis and Preoperative Evaluation

Preoperative workup of BOO following PCa treatment includes assessing the patient's medical history, etiology, and the evaluation of both stenosis length and location. Usually, patients present with obstructive symptoms such as weak stream, hesitancy, post-void residual urine, or urinary incontinence. Moreover, irradiated patients often present with urgency frequency symptoms. Further, BOO treatment following PCa therapy is more likely to cause new-onset incontinence or aggravate preexisting incontinence compared to BOO treatment caused by other reasons [7]. We therefore advise to perform a pad test and patient-reported outcome measurements prior to

any surgical intervention to assess the baseline continence status.

In patients considered for surgical treatment of BOO, physical examination and a prostate-specific antigen test are obligatory to rule out PCa recurrence, which would possibly lead to different treatment strategies. Obstructive symptoms should be investigated by measurement of uroflow and post-void residual urine.

Integral part of the diagnostic workflow is the radiographic imaging of the urethra. Combined retrograde urethrography (RUG) and voiding cysturethrography (VCUG) provides valuable information on the status of both the anterior and posterior urethra. Filling of the bladder is performed during RUG or via an already indwelling suprapubic cystostomy. Radiographic assessment usually reveals a so called “funneled” vesico-urethral anastomosis [28]. This feature may impair the exact determination of VUAS location and length. Given that the anastomosis during RP is performed reconnecting bladder neck and membranous urethra, the funneled area can be part of the VUAS, possibly involving the membranous urethra as well (Fig. 25.2). With regard to this phenomenon, another integral part of the diagnostic process is to perform a cystoscopy (Fig. 25.3). During cystoscopy, a relevant urethral sphincter involvement to the stenosis can be



Fig. 25.2 Vesico-urethral anastomotic stenosis. Combined retrograde urethrography and voiding cysturethrography shows a long-segment vesico-urethral anastomotic stenosis with involvement of the membranous urethra

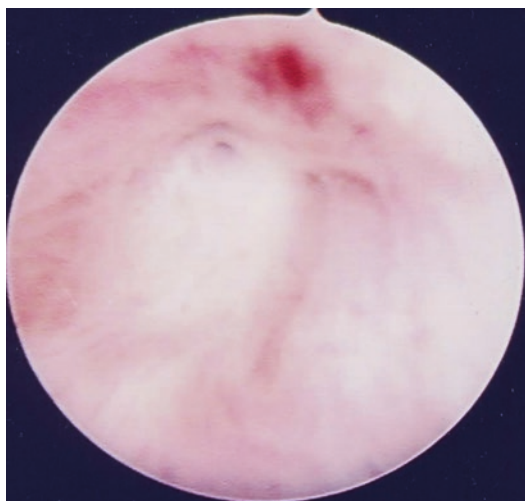


Fig. 25.3 Vesico-urethral anastomotic stenosis. Cystoscopic image of a vesico-urethral anastomotic stenosis with complete obliteration

assessed more adequately compared to isolated radiographic evaluation. Furthermore, cystoscopy allows for estimating the degree of the stenosis. In conclusion, cystoscopy is not mandatory for the evaluation of anterior urethral strictures but may improve adequacy and accuracy in the preoperative assessment of posterior stenoses.

25.2.4 Treatment

25.2.4.1 Prostatic Urethral Stenosis

In the prostatic urethra, sloughing after focal therapy is usually a short-term phenomenon. In most cases it can be managed by clean intermittent catheterization to restore urethral patency and remove necrotic tissue [12]. In case of persistent obstruction, mostly due to side effects of radiotherapy, a TURP or even a photoselective vaporization of the prostate (PVP) may be considered. In these cases, many patients require multiple repeat procedures. In general, TURP or PVP after radiation therapy should be delayed at least 12 months due to the poor healing of highly irradiated tissue [24]. Besides the risk of recurrent obstruction, there is a relevant risk of de novo urinary incontinence and the development of rectourethral or puboure-

thral fistula after TURP [29]. Therefore some authors favor a “cold” loop when removing necrotic tissue [12].

25.2.4.2 Endoscopic Treatment of Vesico-urethral Anastomotic Stenosis

In VUAS, treatment algorithms should start with endoscopic maneuvers such as dilation, incision, or transurethral resection. Many authors propose dilation as the first treatment option, specifically when the membranous urethra is involved [28]. In many cases, this already leads to reasonable success rates [30]. Rates of urethral patency after a single incision or resection range between 40 and 69%, and have been reported up to 91% after multiple interventions [7, 31].

Transurethral incision should be performed at a minimum of two sites. Incision at the 6 o'clock position should be avoided due to the thin plane between vesico-urethral anastomosis and rectum, which may more likely result in fistula formation or direct rectal injury [12]. Incision can be performed using a knife (hot or cold) or laser (holmium). Although high-level evidence is scarce, there are some suggestions of a certain superiority of the laser over cold knife incision [31]. Success rates decrease in repeat endoscopic maneuvers [31]. Therefore, some authors propose the injection of triamcinolone or mitomycin in addition to incision in these recalcitrant contractures. After one or two procedures, success rates of 83 to 89% have been reported [32, 33]. Other authors have reported high success rates after UroLume stenting of the VUAS [34]. However, long-term follow-up has lowered the initial high expectations [35].

25.2.4.3 Surgical Reconstructive Treatment of Vesico-urethral Anastomotic Stenosis

Given that all endoscopic strategies inherit a risk of recurrence, there is a non-negligible number of patients with VUAS refractory to those treatments. In those patients, open surgical reconstruction may be discussed. According to our institutional protocol, we prefer open reconstruction in case of treatment failure after three or

more previous transurethral surgeries. Generally, treatment choices should be patient-centered, but in most cases it is worth considering at least one attempt of open reconstruction. Urinary diversion may be considered a last resort procedure and is discussed in another chapter of this textbook in detail.

Different approaches have been proposed for open reconstruction of the VUAS: the abdominal (retropubic), the peranal, and the combined abdominoperineal approach [28, 36–40]. Results have been generally satisfactory in all of these series.

Lately, robotic reconstruction of VUAS has been described as well. A small cohort of 12 patients was analyzed with 7 patients who underwent bladder neck reconstruction due to recalcitrant bladder neck contracture after endoscopic prostate procedure and 5 patients who underwent reconstruction due to recalcitrant VUAS after radical prostatectomy. Overall success rate was 75% and de-novo incontinence was reported in 18% [41].

We initially relied on the retropubic approach in which the bladder neck is dissected via an abdominal midline incision and scar tissue is excised. Perioperatively, both ureters are stented. We used to expose the urethra using a Grunewald retractor and the anastomosis was performed using five to eight absorbable 2-0 sutures. An indwelling transurethral catheter was placed and VCUG was performed 14 days postoperatively to assess patency and tightness of the anastomosis. In case of no evidence extravasation, the transurethral catheter was removed [37]. In our cohort, primary success rate was 60%. Patients were treated by repeat endoscopic procedures in case of recurrence, resulting in an overall success rate of 95%. Continence rate after open reanastomosis was 64% in patients with sufficient continence preoperatively. The majority of incontinent patients after surgery were offered a subsequent artificial urinary sphincter (AUS) implantation.

Even though success rates were high and incontinence rates were acceptable, we now prefer the transperineal approach at our institution for different reasons. Firstly, using the peranal approach, adhesiolysis and dealing with scarred

tissue may be avoided, as the retropubic approach comes along with working in a pre-operated field. Thus, it may be complicated to identify surgical planes and resection of scar tissue can be difficult. Secondly, mobilization of the urethra to achieve a tension-free anastomosis can be challenging. Additionally, the transperineal approach offers the possibility to suture the reanastomosis under direct visual control [38].

For the open reanastomosis, we rely on an exaggerated lithotomy positioning of the patient (Fig. 25.4) and a transperineal a half-moon incision (Fig. 25.5). The urethra is dissected under digital rectal examination using an O'Connor rectal shield. After complete exposition of the urethral and anastomotic area (Fig. 25.6), the scarred tissue is excised completely. Excision is performed beginning from the urethral lumen until healthy tissue is reached (Fig. 25.7). A transurethral catheter is inserted to allow for better orientation and identification of the distal end of the healthy urethra. Afterwards, wide mobilization of urethra and bladder is performed, guaranteeing a tension-free anastomosis [38]. As the mobilization is generally very far forward into the anterior triangle of the perineum, some authors propose it is usually necessary to separate the crura and

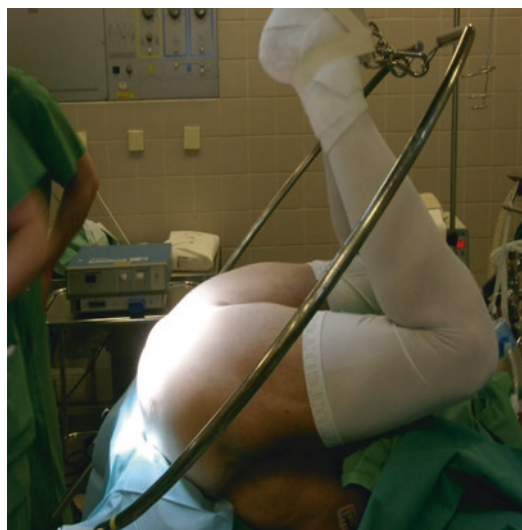


Fig. 25.4 Positioning of the patient for a transperineal reanastomosis. The exaggerated lithotomy positioning provides the best access to the vesico-urethral anastomotic stenosis

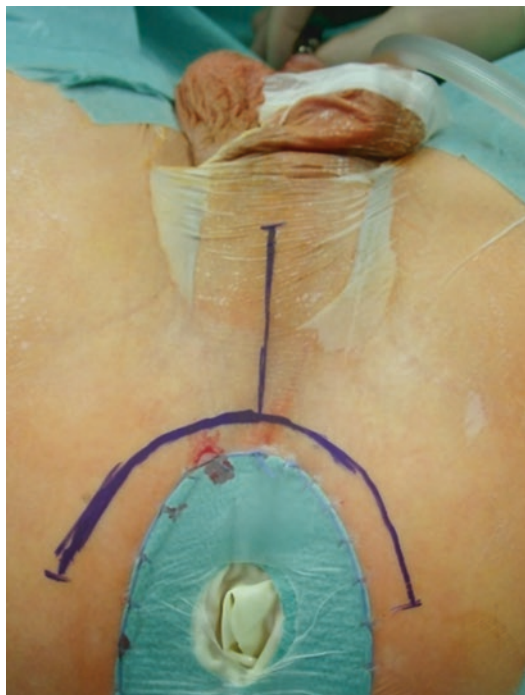


Fig. 25.5 Half-moon-incision used for the transperineal reanastomosis. The incision line is inked blue. The O'Connor rectal shield is already placed

sometimes even necessary to perform an inferior wedge pubectomy for sufficient access [28]. After proper mobilization, a dorsal spatulation of the anterior urethra if performed. The anastomosis is sutured by single knots placed from distal to proximal using 3-0 polylactic acid sutures under direct vision control, if possible (Fig. 25.8). After testing for watertightness, an 18 French transurethral catheter is inserted and reconstruction of the bulbourethral muscles and closure of the peranal fascia as well as suprapubic cystostomy are performed [38]. In case of a complete obliterated VUAS, it may be helpful to perform a cystoscopy using a suprapubic track defined by a preoperatively placed suprapubic catheter [28]. VCUG is performed after removal of the transurethral catheter. If there is no extravasation, spontaneous voiding is allowed and the suprapubic catheter removed in case of tolerable or no postvoid residual urine. Long-term success rates of roughly 87% may be achieved according to an

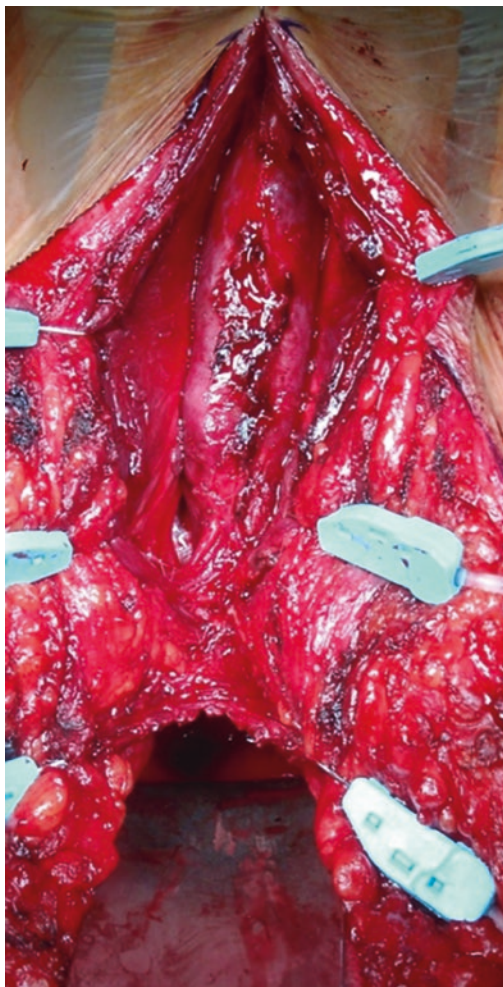


Fig. 25.6 Transperineal reanastomosis. Complete exposure of the urethra, the anastomotic area, and the scarred tissue

institutional protocol. After further endoscopic interventions in case of recurrence, overall success rate was 100%. Of note, all patients were incontinent after surgery and were eligible for (AUS) placement in a second procedure [36].

Due to the previous treatment and the transsphincteric mobilization during transperineal reanastomosis, there is a very high risk of severe postoperative stress incontinence. Therefore, it is obligatory to counsel patients prior to reanastomosis about the possibility of a subsequent AUS placement. Simultaneous performance of reanastomosis and AUS placement



Fig. 25.7 Transperineal reanastomosis. The bulbar urethra is mobilized, the scarred tissue is excised completely until healthy tissue is reached



Fig. 25.8 Transperineal reanastomosis. After proper mobilization, the reanastomosis is sutured by single knots placed from distal to proximal under direct vision control

is generally possible. However, a two-staged procedure minimizes the risk of infection and has been reported by others as well [30, 39]. Additionally, a staged procedure maintains the option of further endoscopic treatment in case of recurrence of the VUAS. Ultimately, the stressed urethra is prone to revascularize, which makes urethral atrophy after cuff placement during AUS more unlikely. Usually, AUS placement is performed 3 months or later after reanastomosis, given the supposed completion of wound healing after this time period. Arguably, transperineal reanastomosis as a

treatment of recalcitrant VUAS is more challenging than a bulboprostatic anastomotic urethroplasty after pelvic fracture injuries [28]. Therefore, we generally do not advise to perform this procedure in previously irradiated patients. In those cases and in patients not willing to undergo open reconstruction, urinary diversion is a reliable treatment option [42].

In selected patients, a bladder neck closure and continent vesicostomy may be offered with reasonable success rates [43]. The surgical technique of this procedure is described in another chapter of this textbook.

25.3 Urorectal Fistulae

25.3.1 Epidemiology and Etiology

Formation of URF following PCa treatment is an adverse event with great impact on quality of life and thus, should be considered a devastating complication. With regard to prostatectomy, rates of rectal injuries are below 1% [44–46], with increasing odds after salvage procedures [44] and the peranal approach [47]. Of note, certain predictors, such as local tumor stage, Gleason grade, lymph node status, surgical experience [44], previous radiotherapy, hormonotherapy, or TURP contribute to the risk of developing a rectal injury [44]. Subsequent URF formation is a relatively rare event ranging from <0.1% [44] to roughly 1–2% [48–50]. Intriguingly, most authors do not differentiate between an early transient fistulation that may heal spontaneously and an epithelialized, established fistula that will persist and will not close spontaneously. Thus, it remains unclear to what kind of injury is referred to when reporting incidence rates. Nevertheless, given the uptake of invasive surgical and non-invasive radiogenic radical treatment for PCa over the last couple of decades, management of URF has gained importance in recent years [51]. The crucial surgical step containing the highest risk of rectal lesion is the vesico-urethral anastomosis. It has been shown that an intraoperative lesion of the rectum is indeed a main risk factor for subsequent URF formation [47].

The incidence of URF following radiotherapy is somewhat higher, ranging from 1–3% [52], and some authors even report a ten-fold higher incidence than in non-irradiated patients [53]. Remarkably, approximately 50% of URF can be attributed to any type of previous radiotherapy [51, 54], and patients with combined treatment strategies (e.g. EBRT or brachytherapy followed by salvage HIFU) are at highest risk of fistulation [55]. Patients suffering from URF following radiotherapy are particularly different from those who underwent surgery. In most cases, they have active disease and the fistula is larger with approximately 2 cm diameter. The tissue is generally compromised with limited mobility

and elasticity due to radiogenic damage. Another important difference is that radiogenic fistulae usually develop significantly later (1–3 years post radiation) compared to fistulae after surgery and are in many cases iatrogenically caused by rectal biopsies in patients suffering from irradiation proctitis [56, 57]. Arguably, given the increase of PCa detection and treatment over the past 15 to 20 years and the uptake of multimodality therapies, URF tend to be larger and more complex than in the past [58].

25.3.2 Diagnosis and Preoperative Evaluation

In order to prevent complicated fistula formation, rectal injury should be ideally recognized and repaired intraoperatively during prostatectomy. Unfortunately this is not always the case and thus, patients may present with urine leakage through the rectum (40%), may report concomitant pneumaturia (67–85%) or even faecaluria (45–65%) [59], which can be generally considered an adverse prognostic symptom [47]. Thorough evaluation should include a detailed history, given that a variety of symptoms may be present, such as nausea, vomiting, abdominal pain, dysuria, or infection. Furthermore, nutritional status and general functional evaluation may support surgical planning. Recently, Hanna and colleagues undertook a great effort to propose an algorithm for evaluation and management of URF in irradiated and non-irradiated patients [60]. Of note, the authors suggest additional evaluation through voiding diaries, 24-hours pad weight testing, and several patient-reported outcome measurements regarding lower urinary tract symptoms, erectile function, and incontinence [60]. Digital rectal examination may allow for fistula detection at the anterior rectal wall and endoscopic procedures (cystoscopy and/or proctoscopy) may improve diagnosis through direct visualization of the fistula canal. Additive radiographic assessment via urethrography and cystography may assist in providing information on fistula location, length, and shape (Figs. 25.9 and 25.10a). It is generally worth considering urodynamics in elderly

patients, given that some baseline symptoms are likely to worsen despite fistula repair, such as urinary and bowel functions [61], and may eventually guide treatment decisions towards alternatives such as urinary or fecal diversion. However, due to the involuntary urine leaks, urodynamic evaluation is not very informative in many cases.

Imaging of the upper tract can be important to rule out ureteral lesions and in cases of extensive fistulae requiring complex reconstruction, multidisciplinary approaches (urology, plastic surgery, colorectal surgery) may help optimize outcomes [60]. Magnetic resonance imaging of the pelvis (Figs. 25.10b and 25.11) may further guide therapeutic decisions in patients with complex fistulae after HIFU or cryoablation, in some cases cavity formation may be seen and eventually impact further treatment modality [28].

25.3.3 Treatment Strategies

Despite recent attempts to help guide clinicians [51, 60], there is currently no universally accepted standardized therapeutical approach for patients suffering from URF. Several factors must be taken into consideration when opting for treatment, such as fistula (location, size, etiology, tissue status) and patient characteristics (age, comorbidities, infection, malignancy). In some patients, immediate fecal or urinary diversion is advisable to reduce inflammation and infection [51]. Generally, there is only a small subset of patients with fistulae healing spontaneously managed by conservative



Fig. 25.9 Conventional lateral cystography showing a fistulous connection between the bladder neck and the rectum

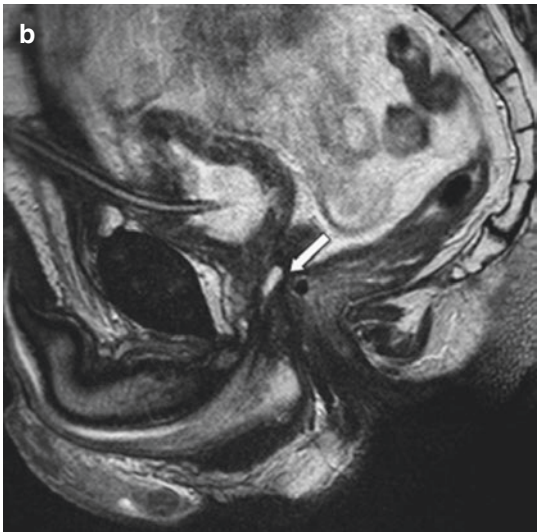
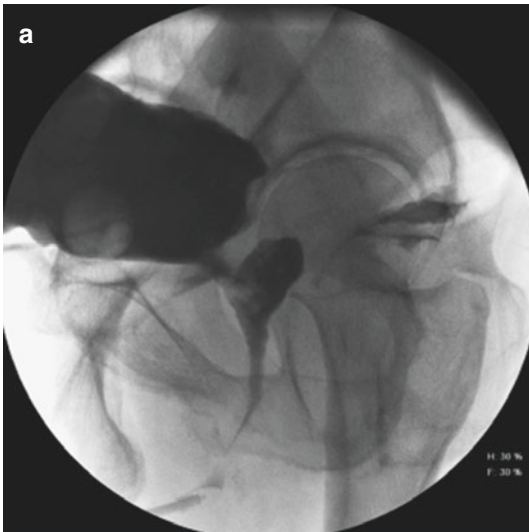


Fig. 25.10 (a) Cystography demonstrates cavitation around the prostate and a fistula to the rectum. (b) Sagittal

magnetic resonance image demonstrates a fistula from the prostate to the rectum (arrow) [70]

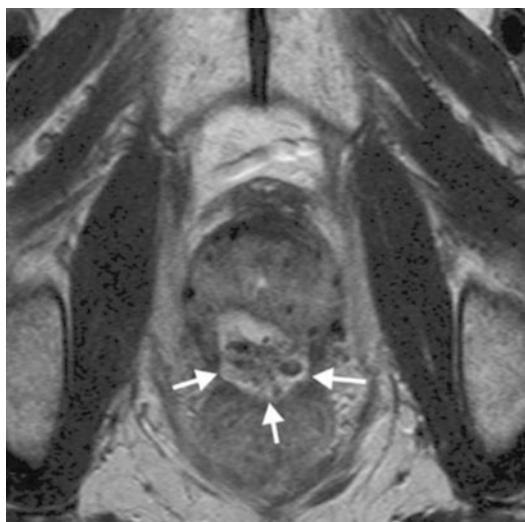


Fig. 25.11 Axial T2-weighted magnetic resonance imaging through lower pelvis. Large fistulous cavity between prostate and rectum (arrows) [56]

or minimally invasive treatment strategies [47, 62, 63]. Spontaneous closure usually occurs within 3 months after therapy before the fistula track has epithelialized. Of note, there are no reports of established URF, which have closed spontaneously and permanently, and this is even less likely in URF following radiotherapy [51, 64]. This has important implications regarding the decision whether to install fecal or urinary diversion (or an indwelling catheter) prior to fistula closure, as it appears to be relevant for symptom control only. Considering the flow gradient from the urinary tract to the rectum, except in patients with very large URF, a transurethral catheter will be more helpful than fecal diversion in most cases.

There are four main approaches to treat URF following RP: transperineal or transabdominal repair [63–65], the trans-ano-rectal sphincter-splitting approach as described by York Mason [66, 67], and the peranal rectal advancement flap as described by Parks [68]. Given that there are some patients opting for conservative therapy [69, 70], surgical options should be thoroughly discussed individually. That said, shared-decision making requires consideration of the underlying goals of surgery, incorporating a meticulous quality of life evaluation.

25.3.3.1 Transperineal or Transabdominal Approach

There are certain advantages of the transperineal and transabdominal (or combined) approaches, which underline their significance as classical urologic procedures. As opposed to York Mason and Parks procedures, the access to the urinary component of the fistula is superior and the urinary tract and the rectum can be adequately separated. This allows for independent closure of both fistula sides and additionally, an interposition flap (gracilis muscle, pedicled dartos muscle, penile skin, levator muscle, gluteus maximus, tunica vaginalis, and bladder) may be utilized to minimize recurrence risk. One of the most popular choices for interposition is the gracilis muscle, as it is usually spared from radiogenic damage, provides optimal vascularity, and can be harvested irrespective of patient age and previous failed attempts of URF repair with satisfactory patient-reported outcomes [58, 61, 71–74]. Transabdominal approaches allow for the use of greater omental flaps, which may improve long-term success but, on the other hand, may entail greater morbidity, longer recovery, and poor exposure in the deep pelvis [75]. Contemporary success rates after transperineal or transabdominal approaches range from roughly 60–100% [60, 61, 65, 74], but one should keep in mind that sample sizes are often small and follow-up is insufficient. In a recent multicenter collaboration, leading reconstructive urologic surgeons pooled 210 patients who underwent transperineal or combined abdominal and peranal URF repair. Overall success rate was 92% and treatment success was slightly lower in the subgroup of patients with previous radiotherapy compared to previous RP (87% vs. 99%) [54]. A certain disadvantage of the transabdominal over the transperineal approach is the dorsal localization of the URF, which requires the reconstruction of the vesico-urethral anastomosis. By the transperineal incision the URF can be approached directly. Of note, the transabdominal approach has certain advantages in patients with radiogenic URF and concomitant cavity formation between prostate and rectum, as the greater omentum may be used as an inlay into the cavity.

There is some additional evidence that URF repair leads to patient satisfaction and improved quality of life, despite small sample sizes and the lack of a prospective evaluation. Hampson and colleagues evaluated 21 men who underwent transperineal URF repair between 2009 and 2016 and evaluated patient-reported outcomes retrospectively [73]. Whereas a non-negligible proportion of patients reported functional issues at long-term follow-up of almost 8 years (urinary incontinence 80%, peranal pain 53%, problems related to the gracilis flap 43%), a remarkable 80% confirmed that surgery positively impacted their life. Another retrospective series evaluated patients who underwent transperineal, transabdominal or combined URF repair between 1993 and 2008. Success rate was 93% in 14 patients with available follow-up data, and all patients were satisfied with the outcome of their surgery translating into an improvement of health-related quality of life in 67% of the study cohort [65].

Needless to say basic surgical principles have to be followed to maximize treatment success, which include removal of devitalized tissue, sufficient exposure, use of healthy tissue when employing interposition flaps, and creating multilayer closures, if possible. Whereas the rectal defect is generally closed in two layers, mobility and flexibility of the urinary tract is usually compromised and mostly only one-layer closure is feasible.

25.3.3.2 Trans-Ano-Rectal Sphincter-Splitting Approach and Transanal Rectal Advancement Flap

Given the necessity to split the anal sphincter when using the technique as described by York Mason [66, 67], this procedure is more likely to be performed in presence of a colorectal surgeon. Several small series have reported outcomes after the trans-sphincteric approach and generally, the advantage of less morbidity and a quicker recovery compared to transabdominal or transperineal procedures is promoted [76–78]. Advantages of the procedure include an excellent exposure of the fistula, at least of the rectal part, and a high closure rate of roughly 70–100% when relying on

contemporary series [79–83]. The same is applicable for the transanal rectal advancement flap. Similar to the trans-sphincteric approach, several modifications and outcomes from small series have been reported for the surgical technique as described by Parks [68, 84–89]. However, given the very small sample sizes (range: 3–12 patients) [68, 85, 86, 88, 89], the interpretability of reported success rates between 67 and 100% is limited.

As opposed to transabdominal and transperineal approaches, a major disadvantage of the York Mason and Parks repairs is that the exposure of the urinary tract via a trans-sphincteric or transanal access is relatively poor. Thus, often it is not possible to close the urinary portion of the fistula and treatment success relies entirely on the sufficient closure of the rectum [79, 90]. Another major concern and specific disadvantage of the minimally invasive/endoluminal repairs and modifications of such is a non-negligible risk to the anal sphincter because of its splitting (York Mason) and the subsequent risk of flatal and fecal incontinence after the procedure [28]. However, in the most contemporary series with data on functional outcomes [79, 83, 91], no durable significant fecal incontinence has been reported. Whereas the original technique did not allow for an interposition flap [66, 67], which may pose risk to postoperative fecal incontinence, some modifications have been described to improve functional outcomes. In a recent series from Dallas, Texas, the authors propose the harvest of a local free graft of subcutaneous fat from the gluteal area to insert it posterior to the urothelial repair to provide supportive tissue interposition [91]. Similarly, in a series from Salt Lake City, Utah, the authors use a demucosalized rectal flap, which is submerged below a full thickness anterior rectal wall closure [77].

25.3.3.3 Fistula Repair Following Radiotherapy

Given significant baseline differences in fistula size and limited tissue pliability in irradiated patients, success rates of URF repair after radiotherapy are generally lower compared to patients following RP [28]. This is particularly relevant for trans-sphinc-

teric or transanal approaches. For example, in their study comparing irradiated and nonirradiated patients, Hanna et al. reported a 100% success in patients who underwent a York Mason repair after RP compared to only 50% success in patients following radiotherapy [60]. Generally, transabdominal or transperineal approaches are more efficient in repairing more complex URF and should supposedly be preferred in irradiated patients if open reconstruction is favored [51, 60, 61, 71, 74, 92]. When counseling older patients with significant comorbidity, salvage RP via an adominoperineal approach and optional inferior pubectomy and omental flap is a valuable option [93]. However, there is some evidence of an increased likelihood of required permanent urinary and fecal diversion in patients following radiotherapy compared to those after RP [60, 94], and this should be considered during preoperative counseling, as upfront urinary and/or fecal diversion may prevent from several unsuccessful and complicated open reconstructive surgeries. That said, cystoprostatectomy with ileal or colonic diversion serves as a therapeutic option in patients with low-capacity bladder, extensive prostatic radionecrosis, or recurrent refractory fistula.

25.4 Conclusions

The incidence and complexity of posterior urethral complications following PCa treatment is increasing, given the advent of novel, multimodal therapies, including radiotherapy, surgical, and ablative approaches. There is a lack of consensus over a standardized algorithm to manage those complications, but several strategies are available to reconstruct a narrowing urethra or bladder neck and repair fistula formation of the posterior urethra. It is important to evaluate all available information related to the disease to allow for adequate patient selection. A post-irradiation complication is of an entirely different nature compared to a complication following RP and this should be taken into consideration during preoperative patient counseling accordingly. In this context, a greater adverse effect of radiotherapy on fur-

ther treatment with regard to posterior urethral complications has to be stressed. However, in any case there are therapeutic options available to improve patient satisfaction and health-related quality of life.

Key Summary Points

- The incidence and complexity of posterior urethral complications following prostate cancer treatment is increasing due to the advent of novel and multimodal therapies.
- There is a lack of a universal consensus on standardized treatment algorithms to manage those posterior urethral complications.
- Endoscopic treatment options for vesico-urethral anastomotic stenosis include dilation, transurethral incision, and transurethral resection.
- After multiple failed endoscopic maneuvers, surgical reconstruction of the vesico-urethral anastomotic stenosis via an open reanastomosis should be performed.
- Urorectal fistulae are rare but should be considered a devastating complication with significant impact on health-related quality of life.
- Urorectal fistulae may be treated by open reconstruction via a transperineal, transabdominal, trans-ano-rectal sphincter-splitting or a peranal approach. An important advantage of the transperineal or transabdominal approach is the superior access to the urinary tract as compared to transanal surgery.
- Post-irradiation complications are entirely different from complications following prostatectomy, as they are more difficult to handle and outcomes are worse. Salvage radical prostatectomy or cystoprostatectomy with urinary diversion is a valuable option in these patients.

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Surgical Reconstruction of Urethral Injury After Artificial Urinary Sphincter Infection-Erosion

26

Francisco E. Martins, Natalia M. Martins,
and William O. Brant

26.1 Introduction

Although the artificial urinary sphincter remains the gold standard for treating men with moderate to severe stress urinary incontinence (SUI), management of urethral cuff erosion is a feared complication that is often debated. Though contemporary descriptions of cuff erosion management report a role for urethroplasty at the setting of device removal, most of these series are limited by single institutional designs with small cohorts and short-term follow-up.

Approximately up to 50% of patients who undergo AUS placement will eventually require surgical revision after first implantation [1]. The predominant causes of AUS device failure are controversial, such as subcuff urethral atrophy, cuff leakage or pressure reservoir balloon (PRB) malfunction, which result in recurrent incontinence. Early cuff erosion most commonly results from unrecognized dorsal urethral injury during cuff

placement and usually present as urinary leakage and periurethral catheter bleeding or hematuria following catheter removal. Most commonly, late urethral erosion, which occurs predominantly within the first 2 years after implantation, is associated with an established capsule around the cuff which does not usually cause urine leakage but hematuria and irritative voiding symptoms instead. Definitive risk factors for delayed cuff erosion have been identified and include initial erroneous selection of an undersized cuff, traumatic endourological manipulation and urethral catheterization with incomplete device deactivation. The diagnosis of cuff infection-erosion, an event characterized by a binomial relationship, is easily made by cystourethroscopy and surgical removal of the cuff is mandatory. In the presence of purulent infection, the entire AUS device must be explanted.

Because “selection is the silent partner of the surgeon”, a rigorous choice of candidates for AUS implantation is critical. As with all surgical complications in general, the most important aspect is avoiding – to the extent possible – the problem in the first place. As such, in this chapter we will review best practices for avoiding erosion and risk factors for erosion before turning our attention to how to manage erosions, many of which are unavoidable. We also need to better know the natural history and clinical course of men who underwent AUS cuff explantation for erosion in large, international cohort studies that could provide valuable insights into future management.

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26.2 Radiation and Other High Risk Factors

Patient risk factors – specifically pelvic radiation, prior AUS erosion, history of urethral stent placement, neurogenic bladder dysfunction and previous urethroplasty – have been responsible for an increased risk of AUS complications, specifically infection and erosion [2]. Some studies have also suggested that patients with additional medical comorbidities, including hypertension, coronary artery disease, and low testosterone are more likely to develop erosion of their AUS [3, 4].

A prior AUS revision, especially for erosion or infection of the cuff, predisposes to another similar event. The reason for this occurrence is still unclear but it is likely that erosion reduces urethral blood supply due to scar tissue it induces. Hypertension and coronary artery disease may also add to the vascular insufficiency leading to tissue breakdown and urethral cuff erosion. This is the leading cause of early AUS revision, with sub-cuff urethral atrophy being the usual cause of late (>12 months) revision.

The role of prior radiation in subsequent cuff infection-erosion rate has been controversial in prior published literature. It is known that radiation causes long-term biological effects such as obliterative endarteritis of small vessels, which result in tissue ischemia, fibrosis, necrosis and abnormal tissue repair. These effects contribute to a higher likelihood of infection-erosion [2–9]. The erosion rate is higher in patients receiving radiotherapy than in patients without a prior history of irradiation. Additionally, in patients who do eventually suffer from erosion, a history of radiation decreases the median time to erosion, versus those without that history [10].

The management strategies for AUS revisions for infection-erosion should include placing the cuff at alternate cuff sites (more proximal or distal to the original one), transcorpal approach and downsizing the cuff size. The use of the UroLume® stent (no longer available in the United States and Europe) across post-erosion stricture site has been recommended by some authors [11]. However, other authors have reported dismal results [12].

Despite patient characteristics and risk factors, there are also surgeon-dependent factors. Not only patient selection is critical, but showering with a chlorhexidine soap starting several days prior to the procedure [13], a thorough scrub of the operating field, meticulous attention to sterile technique, scrupulous use of pre- and possibly peri-operative broad spectrum antibiotics, avoidance of hematomas or excessive use of electrocautery, and copious irrigation of the surgical field are good surgical principles to which to adhere. Delaying device activation for 4–6 weeks, and perhaps up to 8 weeks in patients with fragile urethras or following irradiation are generally followed practices. In high-risk patients, we may postpone reimplantation for up to 6 months to be sure that the urethra is completely healed. If a non-significant stricture develops, a direct vision internal urethrotomy may be attempted once; otherwise, the patient should undergo open urethroplasty. In our experience, one of the authors (FEM) always tries to perform synchronous urethral repair at the time of revisional surgery for cuff infection-erosion (see below). In most cases where the erosion is not circumferential, the urethra is not necrotic and the gap between both urethral ends is not too great, an anastomotic urethroplasty is feasible (data in preparation for publication). This approach, however, is controversial, and a multi-institutional retrospective study suggested that the type of repair at the time of erosion did not influence subsequent urethral stricture rates, although complete erosions were more likely to result in strictures compared to partial erosions [14]. In our opinion, a urethral stent should be avoided at all costs, as we have never had any successful patient after such stent placed at the bulbar urethra or bladder neck followed by AUS implantation later (unpublished data).

26.3 Surgical Approach for Initial Implantation

Positioning/Approach Although the penoscrotal has been touted as an easier approach, especially for those who do not perform AUS frequently, the sites chosen tend to be more distal on the urethra,

of smaller size, and fail earlier [15]. A perineal approach will allow full access to the proximal, mid, and distal bulbar urethra, and is appropriate for single or double cuff placement, as well as periurethral and transcorporeal approaches (Figs. 26.1, 26.2, and 26.3). Regardless of the initial surgical approach used, surgical revision for

an infected and/or eroded AUS cuff is almost exclusively via the perineal route.

Cuff Location(s) and Considerations

Depending on age and comorbidities, it is likely that the AUS will require revision during the patient's lifetime, often several times. For this reason, it is best to plan surgery with the option of later successful revisions. In general, we recommend placing the AUS for the first time at the area of the crus, with subsequent cuffs placed in either proximally (at the area of the perineal body or more proximal) or distally (especially if a transcorporeal approach is used). In the past, double cuffs have been used more commonly, but the major disadvantage of double cuff placement is that the wide area of urethra that is used will take away some future flexibility of placement (see below).



Fig. 26.1 Incision through perineal fat

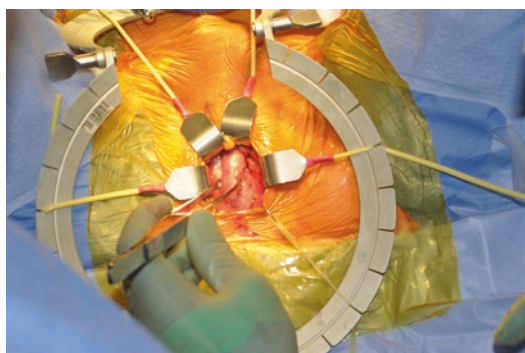


Fig. 26.2 Demonstration of the bulbar urethra



Fig. 26.3 Initial dissection for a periurethral cuff placement

Sharp Dissection vs Blunt The urethra is eccentric within the bulb, with thin spongiosal tissue dorsally. The corpus spongiosum is densely adherent to the tunica albuginea in the area of the septum. If blunt dissection is performed, this may lead to urethral injury, and the dorsal urethra is the most common site of iatrogenic injury. If not recognized, this will lead to cuff erosion. For these reasons, we recommend sharp dissection, with care to visualize all aspects of the dissection until the urethra is completely encircled.

Urethral Irrigation with Proximal Occlusion to Demonstrate Lack of Urethral Injury

(Fig. 26.4) Despite meticulous dissection (never blunt!) of the dorsal attachment of the corpus spongiosum off of the tunica albuginea, it is important to interrogate the urethra for subtle injuries. One author (WOB) has seen an iatrogenic injury that fistulized over several months when it was not recognized. The surgeon had irrigated the urethra but the hole caused by iatrogenic injury was so small that no fluid came out. However, the fistula manifested as a urinoma and was eventually diagnosed with occlusion of the urethra proximal to the cuff site. Intraoperatively, this can be accomplished by tensioning a vessel loop at the most proximal end



Fig. 26.4 Urethral irrigation with proximal occlusion to demonstrate lack of urethral injury

of the dissection and putting fluid into the meatus, either with the catheter in or out. Alternatively, finger pressure can be used to occlude the proximal urethra. If an injury is noted, especially on the dorsal aspect of the urethra, the safest thing to do, especially for occasional implanters, is to leave a catheter in place for healing, stop the case, and do the surgery at a later date.

Single Cuff vs Double vs Transcorporal (TC) Although placement of a **double cuff** (either at one surgery or added later as a staged procedure) is tempting due to initial improvements in continence, we have found that, ultimately, incontinence rates are equal and there is a higher rate of revision and erosion, particularly of the distal cuff [16, 17]. Additionally, the two cuffs remove some location flexibility for placement of future cuffs. For these reasons, we recommend single cuff placement if at all possible.

The **transcorporal placement** approach has several advantages and disadvantages, both practical and theoretical (Figs. 26.5, 26.6, 26.7, 26.8,

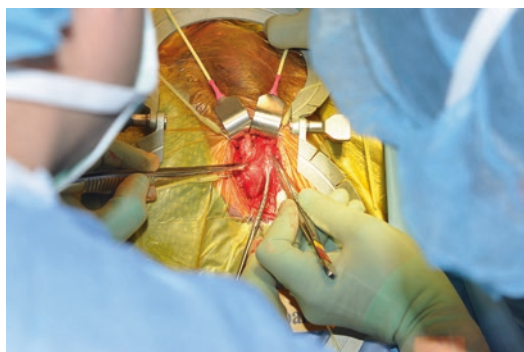


Fig. 26.5 Clearing off the tunica albuginea (TA)

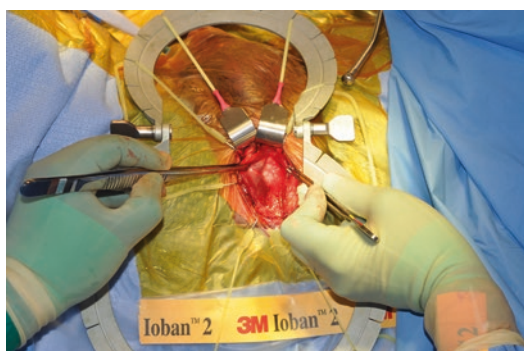


Fig. 26.6 Exposure of the TA

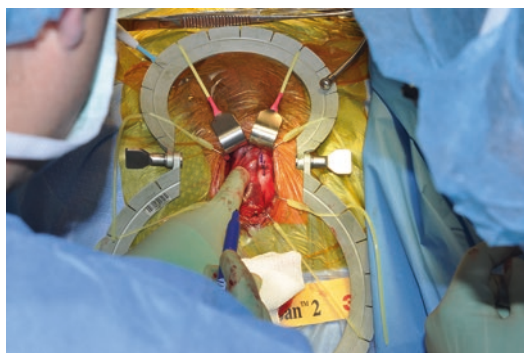


Fig. 26.7 Marking the TA

26.9, 26.10, 26.11, and 26.12). Since a flap of tunica albuginea (TA) is used to separate the dorsal urethra from the cuff, urethral injury is less likely. However, the relative lack of compressibility of the TA makes sizing of the cuff even more important than in the traditional periurethral approach and there is a higher incidence of urinary retention



Fig. 26.8 Placing sutures lateral to the proposed corporotomy



Fig. 26.11 Continuing the dissection under the TA from the contralateral side

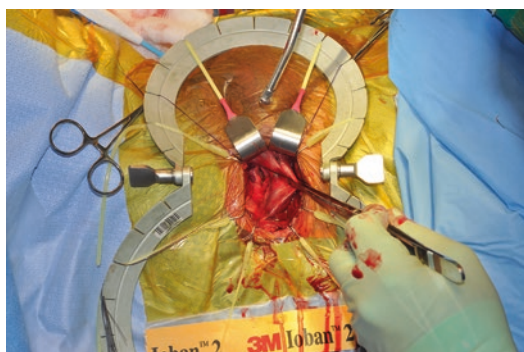


Fig. 26.9 2 cm corporotomy



Fig. 26.12 Both sides are now dissected and a vessel loop has been passed through

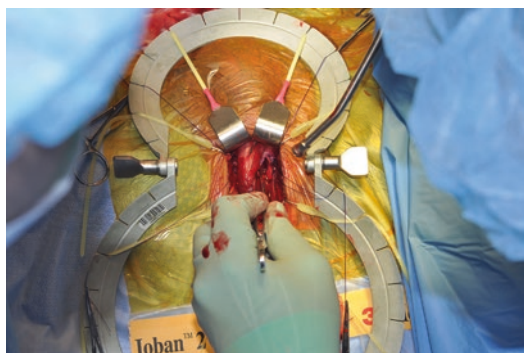


Fig. 26.10 Contralateral corporotomy

after the TC approach, especially in older patients [18]. Theoretically, the TC approach may cause loss of erectile rigidity. This has been suggested via one patient [19] but, if the tunica is closed (as it generally should be to avoid postoperative hematoma), there may not be such an effect. Anecdotally, we have patients who initially expressed no inter-

est in sexual activity but, once continent, became more interested. Intracavernosal therapy or penile prosthesis may be used successfully.

26.4 Strategies for Management of AUS Cuff Infection-Erosion

Is Prevention Possible? AUS cuff infection-erosion is a relatively rare but serious complication due to the complexity and non standardized management of the injured urethra, eventually leading to stricture and fistulation to the perineum as well as the delayed waiting period until reimplantation, if even possible. Major risk factors for cuff infection-erosion have been identified and widely recognized, such as exposure to radiation therapy, diabetes mellitus, neurogenic bladder dysfunction, recurrent urinary tract infections, prior

Table 26.1 Risk factors for artificial urinary sphincter failure

Patient dependent
Age
Insufficient manual dexterity
Mental inaptitude and/or motivation
Higher ASA-classification
Perioperative anticoagulative therapy
Diabetes mellitus
Coronary artery disease, hypertension
Hypogonadal state
Neurogenic bladder dysfunction
Non-compliant or low capacity bladder
Recurrent urinary tract infections
Radiation therapy
Prior surgery for SUI
Additional procedure during SUI surgery
Prior urethral surgery (e.g., urethroplasty)
Urethral atrophy
Compromised/frail urethra
History of urethral stent (UroLume®)
Iatrogenic factors (improper urethral catheterization and endoscopic manipulation with an active AMS800®)
Lack of education of non-urological staff
Surgeon dependent
Inadequate patient selection
Deficient training and experience
Lack of meticulous and sterile surgical technique
Low-volume center surgeon
Deficient preoperative preparation
Long operative time
Device dependent
Non-mechanical
Urinary retention
Erosion
3.5 cm cuff (in high risk settings)
Tandem cuff
Erroneous cuff sizing (too large, too small)
Inadvertent device deactivation
Mechanical
System fluid leak
Insufficient reservoir pressure
Pump malfunction

ASA American Society of Anesthesiologists, *SUI* stress urinary incontinence

urethral surgery, previous AUS cuff revision surgery, prior AUS erosion, hypogonadal state, UroLume stenting, tandem cuff placement and undersized cuffs, especially 3.5-cm cuff (Tables 26.1 and 26.2). The simultaneous presence of sev-

Table 26.2 Causes of revision surgery for artificial urinary sphincter

Early
Erroneous cuff sizing (leading to persistent incontinence or urinary retention)
Insufficient reservoir pressure (persistent urinary incontinence)
Discomfort at pump site
Unsatisfactory accessibility of scrotal pump
Erosion (often due to unrecognized urethral injury)
Late
Device mechanical malfunction (fluid leak, pump malfunction)
Sub-cuff urethral atrophy (leading to recurrent incontinence)
Infection
Erosion

eral risk factors carry a further 25–75% increased chance of erosion [2, 20]. Although the majority of men undergoing AUS device explantation for urethral infection-erosion present within 2 years, late events may occur even beyond 10 years [21]. It is noteworthy to find that still currently a high rate of 16% of AUS erosions was reported in a large series of patients who were submitted to inappropriate traumatic urethral catheterization elsewhere. Inappropriate and traumatic urethral catheterizations, and any endourological instrumentation/manipulation for the same matter, are of paramount importance to consider given the significant morbidity caused, invariably necessitating several operations with impact on patients' future continence status. Most of those who undergo salvage reimplantation have a higher rate of repeat infection-erosion events than primary implantations [2]. In one study, 26% of the urethral erosions could have been prevented, as they were related to inappropriate and traumatic urethral catheterization techniques elsewhere [22]. Patient education, medical alert strategies such as bracelets or necklaces, and informing patients with an AUS to contact a urologist before any catheterization attempt should be strongly recommended measures [23]. The objective of these instructions is to have the device completely deactivated with an empty urethral cuff to allow passage of a small caliber catheter, a 12 French catheter being typi-

cally recommended. Nonetheless, this is an area deserving more reflection and improvement in patient care.

Issues Regarding Synchronous Urethral Reconstruction and Revision for AUS Cuff Infection-Erosion (Figs. 26.13 and 26.14) The options to treat urethral erosions are: (1) urinary drainage alone (by placement of a urethral or suprapubic catheter) versus immediate urethral reconstruction to prevent urethral stricture or fistula formation (Table 26.3). Traditionally, AUS cuff infection-erosion has been managed by urinary diversion with indwelling urethral catheterization or suprapubic cystostomy for several weeks followed by AUS reimplantation after 4–6 months. Recently, it has been reported that simultaneous urethral reconstruction and AUS removal for cuff infection-erosion may prevent bulbar urethral stricture development, thus facilitating AUS replacement later [24]. This concept is attractive since it theoretically may reduce the risk of a urethral stricture, which in turn will imply a 3-stage procedure: removal of the eroded

cuff, urethroplasty and, finally, placement of a new AUS device with its attendant delay for return to normality. However, other data [14] suggests that the type of repair (simple catheter drainage, urethrorraphy, urethroplasty, etc.) at the time of erosion did not influence subsequent urethral stricture rates, although complete erosions

Table 26.3 Treatment options of urethral injury resulting from AUS cuff infection-erosion

Foley catheter placement
Urethrorraphy/Abbreviated urethroplasty
Anastomotic urethroplasty
OMG substitution urethroplasty

AUS Artificial Urinary Sphincter, OMG Oral Mucosal Graft



Fig. 26.13 Cuff erosion into the urethra

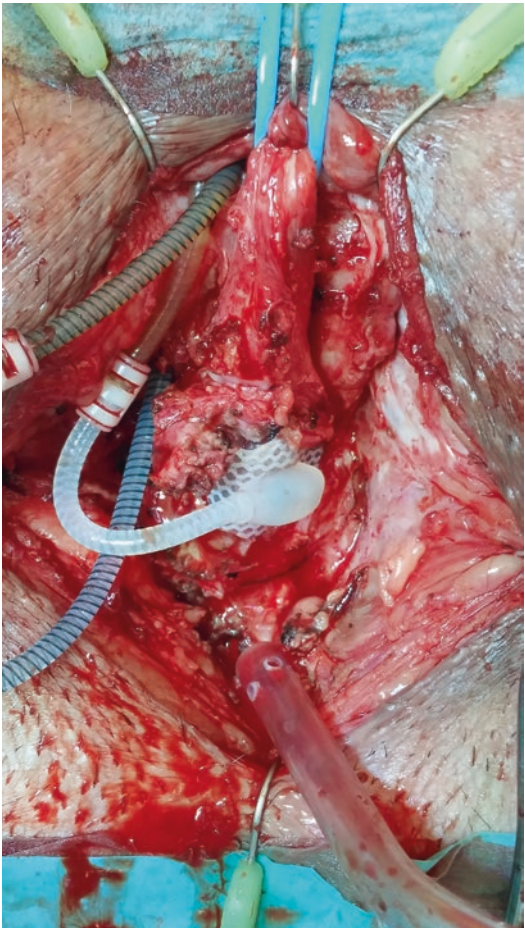


Fig. 26.14 View of urethral erosion within the cuff pseudocapsule

were more likely to result in strictures compared to partial erosions. Although in this study, more strictures were seen after urethrorraphy (40%) vs catheter only (29%) vs urethroplasty (14%), these differences did not achieve statistical significance. Additionally, there was a trend towards increased stricture rates with increased circumference of the erosion. Other authors simply prefer to manage AUS urethral cuff erosions, regardless of the degree of erosion and comorbidities with removal of the urethral cuff placement of an indwelling urethral catheter for 4–6 weeks without concomitant urethral repair at the time of explantation [22]. Another recent series showed an increased risk of post-explantation stricture rate (38.5 vs 5%) for erosions greater than 50% of urethral circumference managed by catheter placement compared to those with less than 50% involvement [25]. Moreover, some erosions are not amenable to in situ ventral closure as proposed by the group from UT Southwestern [24]. In contrast, the study from the Cleveland Clinic showed a higher stricture rate in the urethral reconstruction group compared to drainage alone group, 33% and 17% respectively [25]. Nonetheless, we believe that it is important to attempt reapproximation in all possible circumstances. Several caveats need to be discussed. This patient population is quite heterogeneous, making patient and criteria selection for this strategy somewhat difficult and biased. The local tissue conditions encountered at the time of cuff removal vary from mild inflammatory reaction associated with partial erosion to a much more severe circumferential erosion and more densely fibrotic tissue, to even a catastrophic devastation of the urethra with necrosis, purulence, and significant loss of the bulbar urethra and local surrounding perineal tissues. Lastly, because patient randomization is difficult, the surgical technique adopted for the management of these patients is also variable, ranging from simple surgical debridement and urethrorraphy to formal anastomotic repair or even temporary perineal urethrostomy. Nevertheless, we also have found in our series that in cases where the urethral segment affected has not suffered severe damage and thus is deemed amenable to

immediate repair, we have followed the same strategy of synchronous reconstruction [26]. Nonetheless, it is important to bear in mind that these urethras are at higher risk for complications such as stricture formation and atrophy due to the inherent compromise of the blood supply (Figs. 26.15 and 26.16).

To date, no studies have investigated the success of urethral reconstruction for urethral stricture occurring after AUS erosion and then the subsequent rate of successful AUS reimplantation. It is important to understand the outcomes of the specific group of urethral stricture management following AUS urethral erosion. If the outcomes are indeed worse for AUS reimplantation compared to other well recognized risk factors for erosion, then

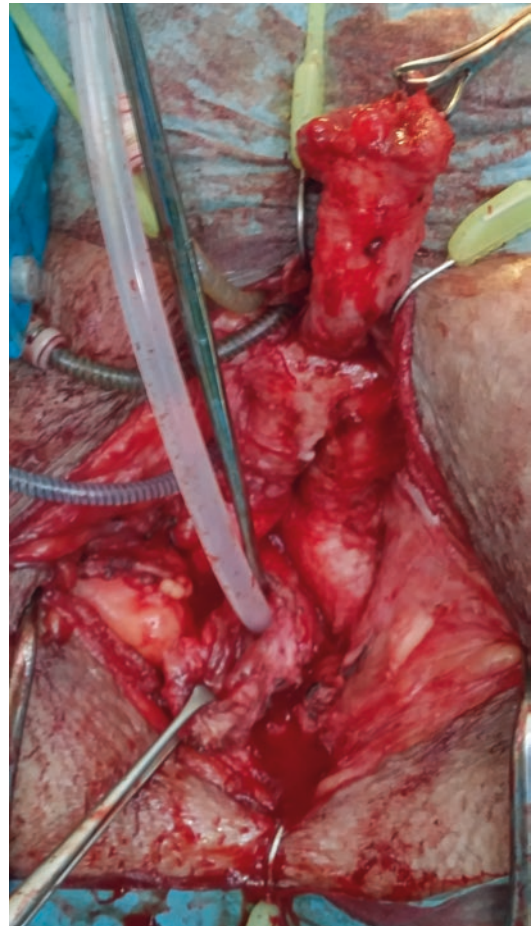


Fig. 26.15 Cuff and erosion site excised and ends prepared for anastomosis

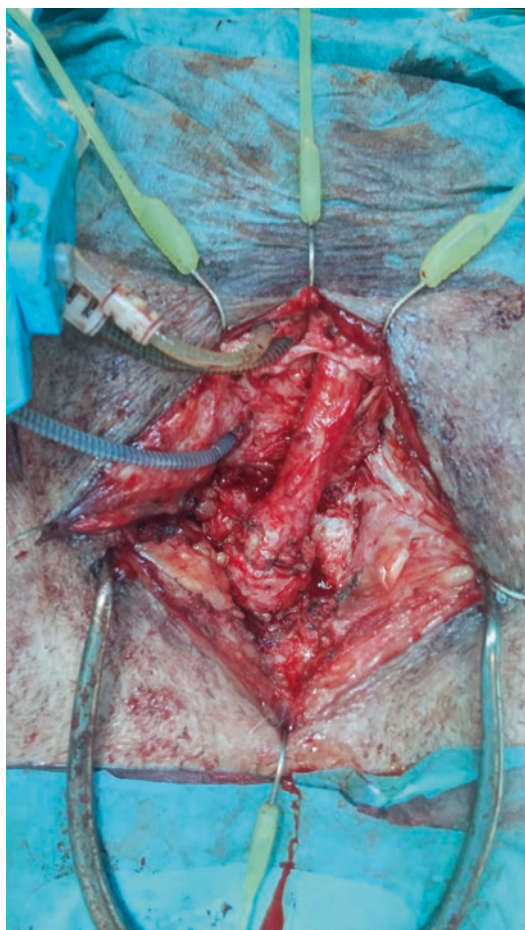


Fig. 26.16 Completion of anastomotic urethroplasty after erosion

simple urethral closure and urinary drainage, either as a suprapubic cystostomy or urethral indwelling catheter, would be preferable. This would avoid the disastrous cycle of urethroplasty-reimplantation- erosion and explantation.

AUS Placement After Treatment of Bladder Neck/Posterior Urethral Stenoses, Urethroplasty and Compromised Urethras Some bladder neck contractures and posterior urethral stenoses do not respond to endoscopic or any other conservative treatment options, with an open repair being the only alternative for a successful outcome. An abdominal or perineal approach (or both combined) are potentially possible with different implications on technical complexity, morbidity

and functional success. The remaining rhabdosphincter mechanism is commonly damaged by either route if not previously already destroyed by multiple repeated endoscopic incisions. Urethral mobilization through the perineal approach to bridge significant urethral defects created by excision of scarred unhealthy urethral segments usually are associated with transection of the bulbar arteries, the urethra relying solely upon the retrograde blood flow from the glans and perforating vessels arising from the penile arteries. Thus, implantation of an AUS would in theory obliterate the retrograde blood flow through the urethra and cause ischemia of the interval segment between the AUS site and the more proximal vesicourethral anastomosis, which in most instances is already atrophic and densely scarred from previous surgery. This anatomic and surgical scenario make this subset of patients the most challenging for successful AUS (re)implantation.

High-risk patients with compromised urethras due to radiotherapy, previous urethroplasty or AUS placement underwent AUS implantation in a study from UCSF group [20]. The worst outcome was reported in the cohort of patients with prior urethroplasty compared to those who had received radiotherapy or prior AUS, that is 44%, 29% and 20%, respectively.

Role of Transcortical AUS Placement This approach is advocated by many urologists in compromised, frail urethras in order to reduce the risk of urethral erosion, especially in its dorsal aspect, thereby increasing the chances of a safe implantation of the AUS around a densely scarred urethra following surgery or other fibrosis-inducing circumstances. This procedure was pioneered by Dr. Webster at Duke University, but the literature about its merits or risks is scanty [18]. A flap of tunica albuginea of the ventral corporal bodies is developed providing bulk to the dorsal urethral and making urethral dissection off the corporal bodies unnecessary. This procedure is particularly recommended in patients with compromised, frail urethras associated with a small caliber, severe atrophy or fibrosis secondary to previous urethral

surgery(ies), radiation exposure, trauma, infection and ischemia. It can also be used in the setting of intraoperative urethral injury combined with a small caliber urethra. Efficacy and satisfaction rates are equivalent to those undergoing traditional AUS cuff placement. However, because of the theoretical risk of erectile dysfunction, this approach should only be recommended to men with erectile dysfunction or those who are no longer interested in sexual activity.

26.5 Conclusions

Urethral cuff infection-erosion is the most common complication of AUS implantation with a tendency to occur within the first 2 years after implantation. This complication tends to weaken the urethral tissues and thus compromise future reimplantations. Patients exposed to radiation, urethral stenting, previous AUS, use of 3.5-cm cuffs, or previous urethroplasty present a fragile urethra at high risk for device erosion and therefore increase the risk of AUS explantation. Other comorbidities including hypertension, myocardial infarction or coronary artery disease, obesity, diabetes mellitus are also more likely to contribute erosions of the AUS. Obesity has been more linked to mechanical malfunction whereas previous radiation therapy and myocardial infarction have been linked to infection-erosion. However, erosion at the site of the AUS should not preclude reimplantation of the cuff even in adverse conditions as long as patients are well motivated and informed of the risks. The number of patients undergoing AUS revisions after infection-erosions is increasing. Patients with a prior erosion of the AUS cuff are more likely to develop a second erosion event. Nevertheless, continence can still be salvaged in a significant proportion of patients using various strategies at the time of revision which can optimize use of the remaining healthy urethral tissue.

AUS reimplantation has been shown to be successful in patients with urethral stricture after AUS infection-erosion. However, there is a high rate for a second erosion after AUS reimplantation in this subset of post-urethroplasty patients

even in the short term. Despite anatomic concerns about poor blood supply, the risk of proximal urethral necrosis is slow.

Erosion of the urethra can be difficult to treat. Those involving less than 50% of the urethral circumference are considered lower risk erosions and can be managed with ventral urethral closure and/or catheter drainage with low risk of subsequent stricture formation. In contrast, severe erosions probably benefit from immediate anastomotic urethroplasty whenever feasible. In situ urethroplasty may offer promising results in the prevention of urethral stricture formation after AUS cuff erosion. The time to AUS reimplantation may also be reduced compared to traditional management. Unfortunately, there are no reliable data on replacement of an AUS after urethroplasty for strictures resulting from AUS cuff erosions.

Transcorporal implantation is a reliable and recommended alternative, especially in the setting of compromised, frail urethras or following urethroplasty. This technique can avoid further urethral injury and may reduce erosion rates, and many surgeons (including the authors) favor this essential step.

Appropriate preoperative counseling is critical for patients' understanding of the need for revision and subsequent satisfaction with ultimate results. In addition, patients must be followed up diligently for a period of years after implantation, to recognize and address issues that may arise from an AUS. Or in those saturated of surgeries!!!

A notable proportion of men never undergo re-implantation of a new device, although the reasons for this remain unclear. An initial erosion event likely results in the development of a fragile urethra that significantly increases the likelihood of numerous future device revisions in the setting of planned reimplantation. Urethral reconstruction at the time of cuff removal is, however, associated with future device success in most cases.

Lastly, in a few patients in whom further reconstruction is neither possible or advisable, or who wish no further surgical attempts, urinary diversion remains a last resort.

Key Summary Points

- Although still the standard treatment for post-prostatectomy urinary incontinence, the AUS is an invasive procedure with an inherent risk for infection and erosion.
- Urethral cuff infection-erosion is the most common complication of AUS implantation with a peak of occurrence within the first 2 years after implantation.
- Erosion-infection tends to weaken the urethral tissues and thus compromise future reimplantations.
- Exposure to radiation, urethral stenting, previous AUS, use of 3.5-cm cuffs, or previous urethroplasty are adverse factors that lead to a fragile urethra and consequently an increased risk for device erosion. Despite anatomic concerns about poor blood supply, the risk of proximal urethral necrosis remains slow.
- Other comorbidities including hypertension, myocardial infarction or coronary artery disease, obesity, and diabetes mellitus are also more likely to contribute erosions of the AUS.
- Although the number of AUS revisions after infection-erosion is increasing, erosion at the site of the AUS should not preclude reimplantation of the cuff even in adverse conditions so long as patients are well motivated and informed of the risks.
- An initial erosion event likely results in the development of a fragile urethra that significantly increases the likelihood of numerous future device revisions in the setting of planned reimplantation.
- Although AUS reimplantation has been shown to be successful in patients with urethral stricture after AUS infection-erosion, there is a high rate for a second erosion after AUS reimplantation in this

subset of post-urethroplasty patients even in the short term.

- Erosion of the urethra can be difficult to treat. Those involving less than 50% of the urethral circumference are considered lower risk erosions and can be managed with ventral urethral closure and/or catheter drainage with low risk of subsequent stricture formation. In contrast, severe erosions probably benefit from immediate anastomotic urethroplasty whenever feasible.
- In situ urethroplasty may offer promising results in the prevention of urethral stricture formation after AUS cuff erosion. The time to AUS reimplantation may also be reduced compared to traditional management, and urethral reconstruction at the time of cuff removal is associated with future device success in most cases.
- Transcorporeal implantation is a reliable and recommended alternative, especially in the setting of compromised, frail urethras or following urethroplasty, avoiding further urethral injury and potentially reducing erosion rates.
- Lastly, in a few patients in whom further reconstruction is neither possible or advisable, or who wish no further surgical attempts, urinary diversion remains a last functional resort.

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Surgical Urethral Reconstruction After Failed Urethral Stents

27

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27.1 Use of Stents for Urethral Stricture

Urethral strictures are typically caused by inflammation or trauma. Endoscopic treatments of a urethral stricture is a controversial issue as the success of different endoluminal therapeutical options depends on numerous factors related to the procedure type, the stricture etiology, length and location, the degree of spongiosclerosis and the magnitude of the inelastic scar within stricture. Visual urethrotomy evolving full-thickness incisions through the depth of the scar or urethral dilatation also result in further scarring after damage of epithelium, spongiosal tissue and surrounding muscle fibers.

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Urethral stents were introduced in the 1980s with the intention to prevent scar contraction after dilatation or urethrotomy. Both permanent and temporary stents were introduced, both being subject to either staged removal or periodic change. Initially the stents were designed to be placed after dilatation as an alternative to internal urethrotomy for recurrent bulbar strictures. Unfortunately their widespread use has led to very disappointing results, not only due to complications, but also due to the daunting task of dealing with removal of the embedded prosthesis and difficult late urethral reconstruction [1].

27.1.1 History of Permanent Stents

The self-expanding Wallstent was developed for vascular disease by Hans Wallstent, taking into account a wire banding braided technology also used to the manufacturing of coaxial cables. In Urology it mainly served to maintain the patency of a stenosed bulbar urethra after dilatation as initially described by Milroy in 1988 [2]. Treatment of urethral stricture using UroLume (American Medical Systems, Minnetonka, Minnesota) urethral stent was approved by the Food and Drug Administration since 1988 and since then distributed in many countries until being discontinued in 2011. This endoprosthesis manufactured in Switzerland was biocompatible, flexible and self-expanding, and rapidly evolved to be considered

a good alternative to dilatation and internal urethrotomy to treat recurrent bulbar strictures [3]. At that time urethroplasty was too often performed only after repeat failure of endoscopic methods because urologists erroneously believed in a “reconstructive surgical ladder” and only considered urethroplasty after repeat failure of endoscopic methods [4, 5].

Soon after the UroLume was developed, another meshed knitted stent, the thermo-expandable Memotherm (Bard, Murray Hill, New Jersey) became available. Its use was indicated for urethral strictures less than 3 cm long with at least a 10-mm interval of healthy urethra present distal to the external sphincter. The stent was intended to be at least 10 mm longer than the stricture, as 5 mm were estimated to be added to each end of the stricture [6]. The main proposed advantage of both types of permanent stents was that urothelium growing through the interstices and covering the wires would theoretically prevent it from migration and would prevent it being exposed to urine and thus prevent encrustation or infection. This turned out to be their main disadvantage as urethral stricture would progress through a process of spongiosclerosis and hyperplastic overgrowth resulting in restenosis adjacent to and inside the prosthesis (Fig. 27.1). The patients with the progression of the disease would present with numerous persistent problems



Fig. 27.1 2.5 cm UroLume stent on bulbo-membranous urethra with hyperplastic overgrowth causing restenosis inside the prosthesis

including perineal pain, urinary retention and urinary infections.

Hyperplastic tissue ingrowth and intra-stent tissue frequently occurred in post-traumatic strictures [7]. For that reason permanent stents were considered contraindicated in strictures after trauma. Additionally, because of their wide caliber and cylindrical shape, permanent stents could only be useful in the bulbar urethra. In the other parts of the urethra their use was contraindicated because due to the sharp ends causing pain and further urethral injury. In addition, urethral stents placed within the previous urethroplasty beds could not become entirely incorporated and epithelialized and were thus prone to stone formation and recurrent infections. For all these reasons the results were often disappointing and at a longer follow-up demonstrated high rates of restenosis. Regrettably, only 13% of the implanted patients had subjectively satisfactory results at 10 years [8]. A re-intervention due to stent-related complications occurred in one out of every three patients in the long term [1, 9]. As a result, the experts in urethral reconstruction have not been using them in any situations including for the “ideal” candidates with bulbar urethral strictures. It is a consensus that stents should never have been used for penile urethral strictures, long strictures or urethral scarring after pelvic floor urethral distraction defects. However, due to their ease of use, the stents were frequently misused, and even placed in tandem for longer strictures (Fig. 27.2).

We really do not know how many permanent stents have been explanted in the long term and there is no knowledge of how many patients are still bearing these type of endoprosthesis. Still though, despite it is now more than 15 years that stents they are not available the patients return with re-strictures and pose a very interesting challenge to the reconstructive centers worldwide [10].

27.1.2 Temporary Stents

Results with the temporary stents were not as disappointing as those with the permanent stents,



Fig. 27.2 Two 2.0 cm UroLume stents placed on pendulous and bulbar urethra with re-stricture adjacent to both proximal and distal ends of the tandem stented segment

which would explain why they are still in use today being used occasionally for treatment of recurrent urethral strictures, post-prostate cancer treatments, urethrovesical anastomotic stenosis, recurrent ureteral stenosis and uretero-ileal anastomotic stenosis as well.

Memokath (Pnn Medical, Denmark) is a bio-compatible endoprosthesis made of nickel and titanium alloy (nitinol) that anchors by expansion of its proximal end in response to a warm water instillation after being inserted through a lumen opened by direct vision internal urethrotomy or progressive dilatation. In contrast to permanent stents, it is not embedded into the mucosa. This quality in combination with its thermal shape-memory allow for an easy transurethral removal. However, due to the stent's constant exposure to urine, the initial reports also described luminal narrowing due to encrustation in 1 out of 4 patients and recurrent stricture in 1 of 5 [11]. Complications were shown to increase with time as epithelial hyperplasia tends to develop at around 1 year follow-up [12], which makes this device useful only for temporary stenting.

A multicenter randomized controlled trial demonstrated that patients with recurrent bulbar urethral stricture treated with Memokath stent after dilatation or internal urethrotomy have maintained their urethral patency longer than those treated with dilatation or DVIU alone [11].

However, another feasibility study where Memokath stent was used for treatment of recurrent bulbar strictures, has concluded that this treatment has significant side-effects and is not clinically useful [13]. Also urethroplasty in these cases is totally feasible and is very effective to achieve and maintaining urethral patency after non-desired Memokath urethral re-stenting [14].

Allium stent (Allium Medical, Caesarea Industrial Park, Israel) has a nitinol skelton covered with a biocompatible polymer that is resistant to urine environment, thus acting as an impermeable walled tube that prevents tissue ingrowth into the lumen. It can be removed easily, even 1 year after implantation, by pulling its downstream end with an endoscopic forceps causing the stent to unravel and to be taken out as a tape. Clinical experience with Allium is scant, but at least this device does not seem to suffer migration or problems at the time of endoscopic extraction [15, 16].

27.2 The Problems of Urethral Stenting

Urethral stent placement was enthusiastically incorporated in the 1990s as a minimally invasive therapy for recurrent bulbar strictures with promising early results in the absence of extensive peri-urethral fibrosis [2, 17–19]. However, long-term results showed progressive deterioration of the initial attractive results due to hyperplastic overgrowth with secondary restenosis, stent migration, encrustation, urinary infection and other side effects that impacted patients' quality of life and included pain with erections and complaints of postvoid dribbling [1, 5, 20]. This knowledge of the delayed complications has replaced the initial good acceptance of this technology with extreme precaution. The disappointment came not only from the high rate of stricture disease recurrence, but also from the degree and complexity of complications requiring operative interventions (urethral dilatation or urethrotomy for stricture, transurethral resection for hyperplasia and litholapaxy for encrustation) and occasionally quite elaborate definitive stent removal [1, 7] (Fig. 27.3).



Fig. 27.3 3.0 cm UroLume stent with severe distal urethra stenosis in a patient performing long-term auto-dilatation before definitive stent removal and urethral reconstruction

While endoscopic removal of a prostatic urethral stent can be feasible and safe with use of a holmium laser [21], open stent explantation with urethral reconstruction for a failed urethral stent is frequently necessary and is always challenging [5, 22]. Severe polypoid hyperplasia and inflammatory infiltrate, the histological changes associated with long-term urethral stents, discourage endoscopic removal in most cases [23]. Endoscopic stent removal wire by wire is possible after transurethral stent cutting [9]. However, an open en-bloc removal of the scarred urethra together with the entrapped stent has been the preferred choice in cases requiring a more definite reconstruction [5].

The thermo-expandable Memokath stent was designed for easy implantation and removal from urethra. However, being often left in place for 6–12mo before removal, it is not devoid of encrustation and recurrent stricture. This treatment should be considered as a temporary option, and should not be used in patients who are fit for urethroplasty [13, 24, 25]. Additionally, a recent report has shown good results after urethroplasty in patients with previous Memokath stent, and could contribute to a further argument discouraging temporary stenting in patients willing to undergo a definite reconstruction [14].

27.3 Management of Re-Stricture after Urethral Stent Use

Management of re-stricture after urethral stent placement is becoming an infrequent situation now that urethral stents are very rarely used as primary treatment for complex urethral stricture. However, technically speaking, various valid alternatives exist for performing urethroplasty with simultaneous stent removal [22]. Several methods of one-stage repair have been described as successful, and involve either a complete full-segment urethral excision or urethral preservation with tine-by-tine stent extraction following longitudinal urethrotomy [26–28] (Fig. 27.4). However, a two-stage surgery can be sometimes a more judicious decision, always to be undertaken in an individual basis, depending on the degree of fibrosis surrounding the stent, the length of the stricture and its concrete topography. There are different options that can be used for a two-stage repair, including techniques involving the use of buccal mucosa patch to augment temporary urethrostomy. In some occasions, diffuse periurethral abscess with total lack of urethral patency may preclude immediate reconstruction, in which case a definite perineal urethrostomy can be the only choice. The decision on how to perform a stent retrieval and urethral reconstruction can be difficult and management needs being decided on an individual basis.

27.3.1 Full-Segment Excision and Urethral Substitution

Full-segment excision of the urethra that harbors the permanent stent was historically the most frequent approach used in the past. The classical approach for urethral reconstruction after this “radical” stent removal included a mandatory anastomotic urethroplasty for a more posterior location for shorter strictures, and a two-stage urethral reconstruction, often with buccal mucosa graft, for longer and more anterior strictures [26, 29].

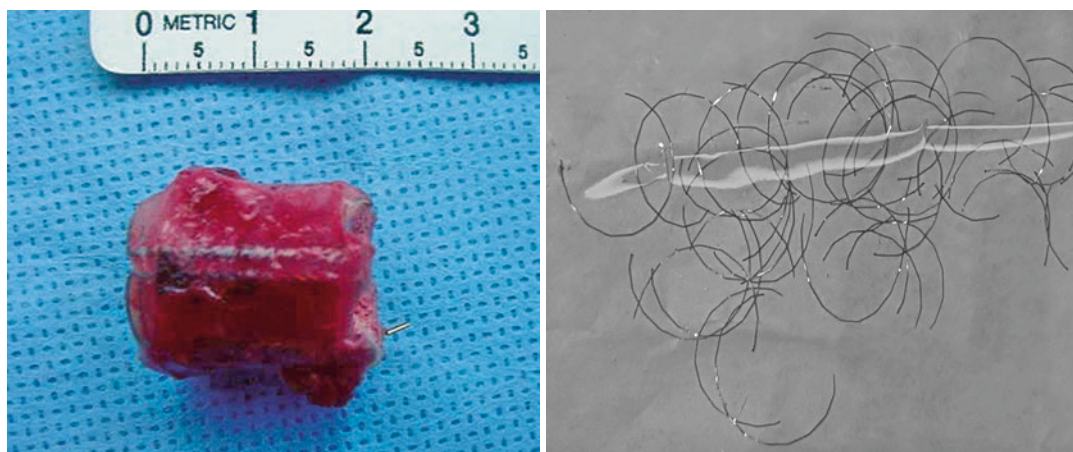


Fig. 27.4 Full-segment urethral excision with 2 cm Urolume stent (left) and individual tine-by-tine stent extraction of two Urolume stents (each composed of 24 individual wires) following longitudinal urethrotomy (right)

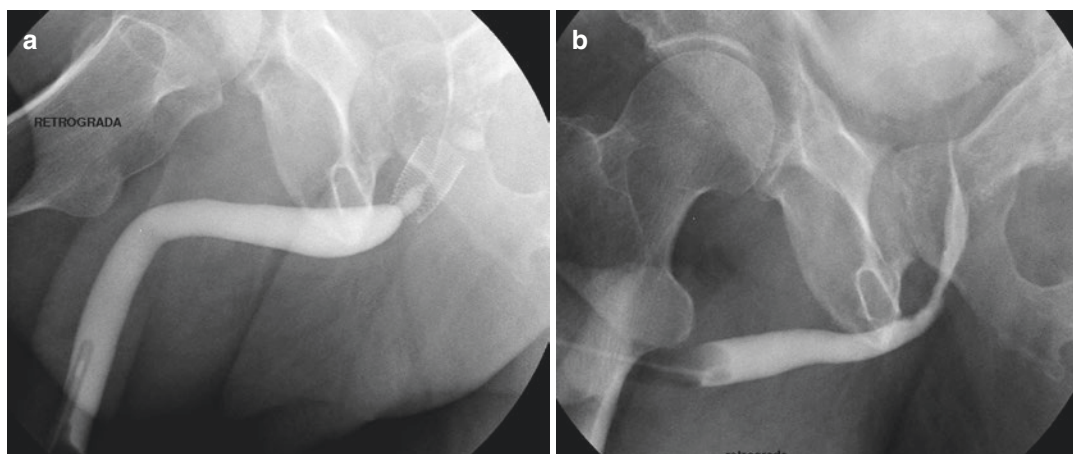


Fig. 27.5 2.5 cm Urolume stent with restenosis in the distal end treated with excision and primary anastomosis: retrograde urethrogram before (a) and after (b) surgery

Excision and primary anastomosis is feasible after complete urethral excision when the excised segment is short, i.e. less than 3–4 cm (Fig. 27.5). The bulbar urethra is mobilized from the corpora cavernosa and a dilator is passed through the meatus into the urethra until a firm nodule is felt in the corpora spongiosa at the site of injury and the urethra is transected at this level. The fibrotic tissue is excised on the proximal and the distal end of the urethra until healthy urethral mucosa is exposed. The urethra is spatulated on opposite sides into normal pink urethra and the anastomosis is performed with a single suture line of inter-

rupted 4/0 polyglactin sutures posteriorly. Anteriorly a two-layer anastomosis is done. The first layer approximates the urethral mucosa and the second layer approximates the corpora spongiosa. The bladder is catheterized and the catheter is left to dependent drainage for several weeks [30, 31].

Augmented anastomotic urethroplasty using a dorsal buccal mucosa graft is utilized to cover defects of up to 5 cm in the bulbar urethra. During this procedure the scar tissue involving both urethra and spongiosum is totally removed. The bulbar urethra is circumferentially dissected from

the corpora cavernosa and completely transected. The distal and proximal edges are open and spatulated along the dorsal surface. The oral graft is quilted with absorbable sutures on to the corpora cavernosa, and distal and proximal apices of the graft are fixed to the distal and proximal mucosal edges (Fig. 27.6). Alternatively, fibrin glue can be used for graft fixation. Distal urethra is pulled down and sutured to one-side graft margin, and so is the proximal urethra while being pulled up. Distal and proximal urethral edges are sutured together in the ventral surface as an end-to-end anastomosis. The urethral mucosa is sutured to the oral graft on the other side [32, 33].

Combined ventral onlay fasciocutaneous flap with dorsal onlay buccal grafting can also be a good option for a single-stage segmental urethral replacement in some cases [34, 35]. A more risky, but feasible alternative for reconstruction of long bulbar urethral segments in a single step is a full-segment tubular pedicled skin graft urethral sub-

stitution (Fig. 27.7) or a dorsal buccal mucosa graft combined with an anterior pedicled gracilis myocutaneous flap [36]. Also inlay skin flap can also be used as a first step to be followed by later complete tubularization and closure at a second-step [35].

A two-stage procedure or even perineostomy alone can be the most appropriate option in some patients with devastated urethra and a very long history of stricture, chronic dilatations after stent placement, presence of perineal abscess or fistula (Fig. 27.7). A V-flap developed with scrotal skin may serve to avoid skin retraction. Three layers including the urethral mucosa, the adventitial of the corpora spongiosus and skin are incorporated in absorbable stitches and the urethroostomy is left intubated for 2 weeks or longer [5]. The outcomes of perineal urethroostomy are acceptable in these difficult cases, but as the longitudinal blood supply may also be compromised, these cases often need subsequent

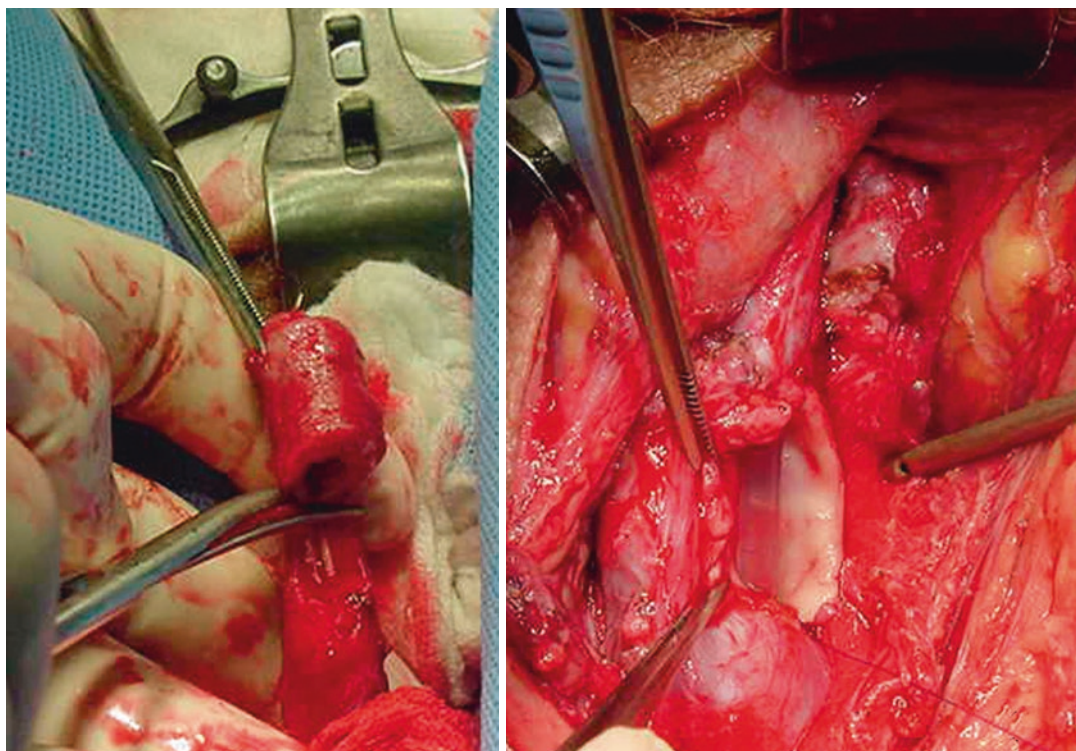


Fig. 27.6 Full-segment urethral excision with 2.5 UroLume stent treated by augmented anastomotic urethroplasty using dorsal buccal mucosal onlay graft

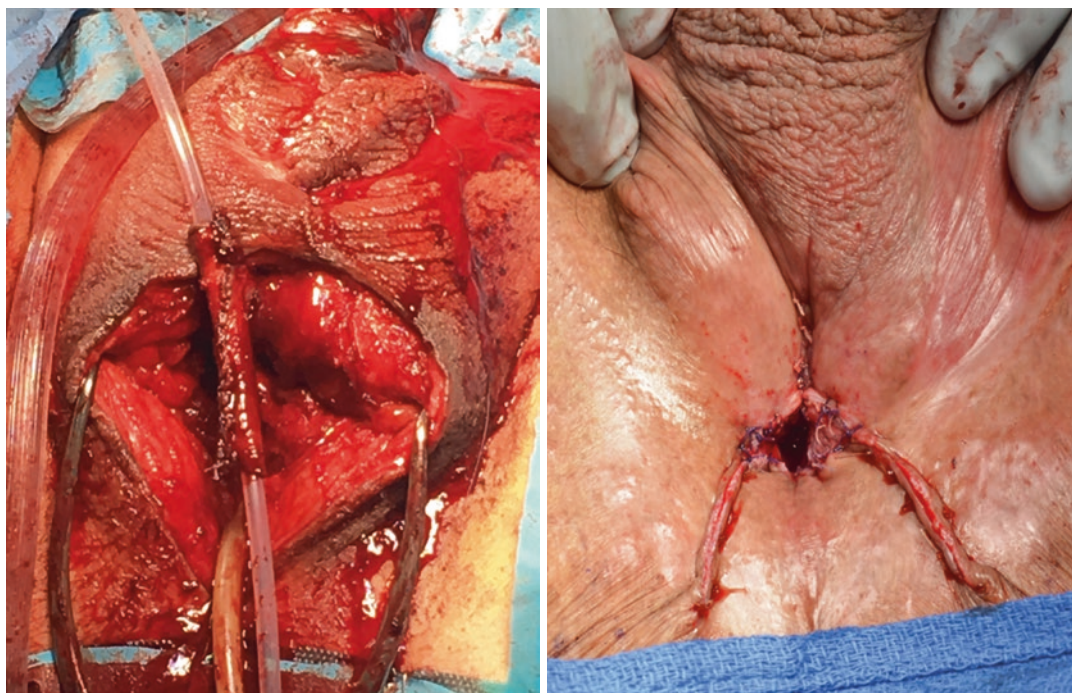


Fig. 27.7 Full-segment tubular pedicled skin graft urethral substitution (left) and urethrostomy (right) in cases with devastated urethra

dilatation. In our experience, a two-stage procedure may not always be a more successful option compared to a one-stage reconstruction, and is still subject to high index of failure [10].

27.3.2 Tine-by-Tine Stent Extraction and Buccal Mucosal Graft Urethroplasty

Firm longitudinal section of the urethra that harbors a permanent stent using strong scissors opens the metal structure thus transforming a finger-glove structure into 24 isolated wires. This maneuver makes the individual wire extraction out of the urethral wall easy to be performed, as when taking fish-bones out of fish meat. The maneuver prepares the urethra for augmented urethroplasty that follows (Fig. 27.8).

Fisher and Santucci were first to describe buccal mucosal graft urethroplasty with the removal of the stent tine by tine as a feasible option of one-stage repair [27]. These authors

suggested a ventral onlay buccal mucosal graft placed in the ventral defect as a least invasive approach. Identification of the boundaries of the stricture can be helped both by catheter placement and/or flexible cystoscopy. Zinmann et al. reported a similar technique, but based it on a dorsal buccal graft onlay, also with excellent outcome [37]. Gelman and Rodriguez in their series have confirmed that a substitution dorsal onlay graft was a feasible option as a single-stage reconstruction, especially to cover longer strictures in which excision and primary anastomosis would not allow for a tension-free primary repair [28]. Chapple and Bhargava have also noted that all patients treated in their series with buccal mucosal graft substitution were free of failure [22].

Buckley and Zinman reported in 2012 their very interesting experience with removal of UroLume stent with diseased urethra preservation and simultaneous reconstruction in one-stage. They preferentially used dorsal urethrotomy with individual wire removal and augmented primary

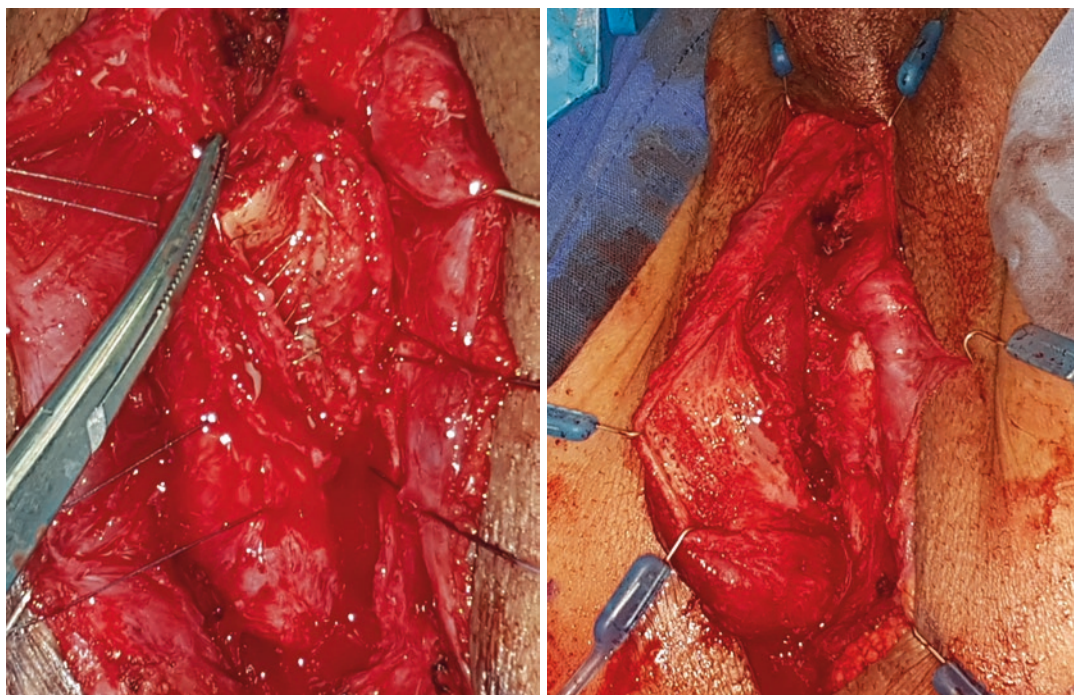


Fig. 27.8 Non-transecting approach with longitudinal urethrotomy and extraction of wires followed by dorsal buccal mucosa onlay graft

ventral anastomotic urethroplasty [38]. In most of their cases after the stent extraction and repair, the patients needed no additional dilatation or ancillary procedure. This clever approach has gained popularity, but unfortunately, severe scarring and fibrosis sometimes do not allow for a clean time-by-time removal strategy.

Dorsolateral urethral dissection and dorsal onlay urethroplasty as proposed by Kulkarni et al. [39] allows for the preservation of the one-sided vascular supply to the urethra and its entire muscular and neurogenic support. Additionally, it utilizes an effective non-transecting augmentation of long diseased segments (Fig. 27.9). Angulo et al. have described results of multi-institutional experience using this technique for urethroplasty after stent section and individual wire extraction [10], as well as the results of primary deferred reconstruction after temporary stent extraction in patients undergoing complications such as pain, stone formation or stent occlusion due to epithelial hyperplasia [14].

27.3.3 Endoscopic Retrieval of a Temporary Stent and Urethral Reconstruction

After permanent urethral stenting felt out of favor, the concept of a “time-trial” emerged with the intention of stabilizing the scar process. Nitinol stents, either uncovered or covered by a biocompatible polymer has been used to treat recurrent bulbar urethral stricture. As described in the earlier sections, these stents are not incorporated within the urethral wall, and that facilitates endoscopic extraction [12]. However, failure to prevent recurrence of stricture, stone incrustation and other complications have been described for both Memokath and Allium [11, 13, 22, 40]. Jordan et al. reported on 30% of the patients with Memokath who suffered pain, especially with erection or intercourse [11], while Barbagli et al. described re-estenosis in 69% of their cases [13]. Similarly, Allium, stent incrustation and distal burying occurred in 20%

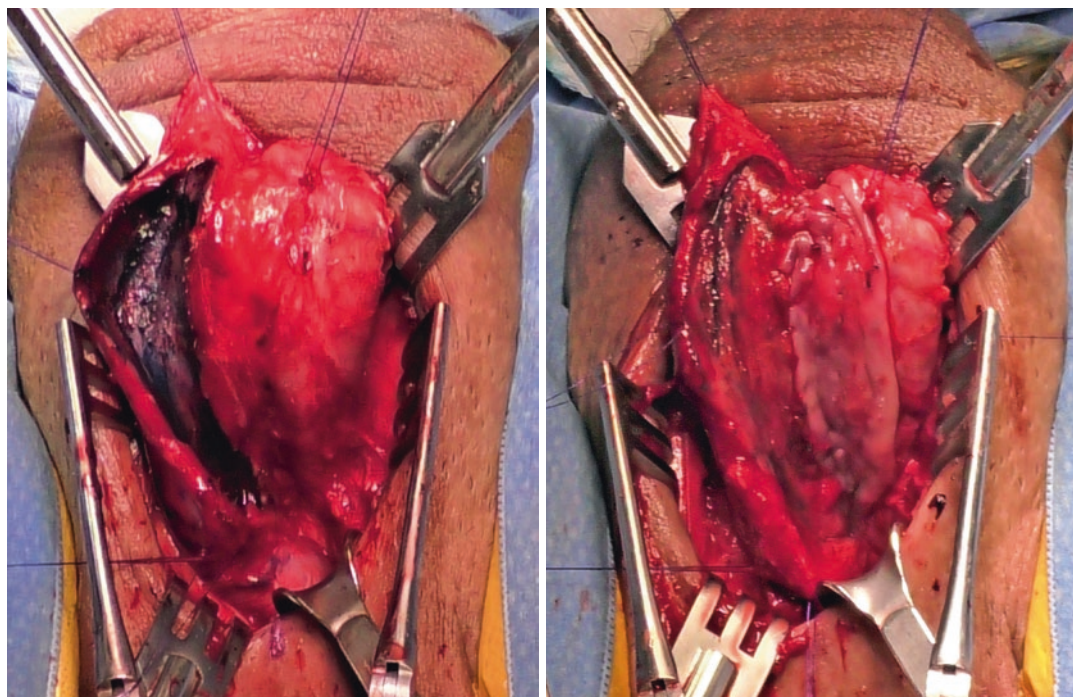


Fig. 27.9 Tine-by-tine removal and urethroplasty with one-side dissection and dorsolateral buccal mucosal onlay graft (Kulkarni technique) for a very long diseased segment

of the cases and failure to control stricture in 40%, both in the short-term [40].

Temporary urethral stenting should only be used in patients who are not candidates to undergo urethroplasty [13, 22, 23]. There is no experience that describes the role of urethroplasty after the withdrawal of failed Allium stents, but there is a very satisfactory experience describing deferred urethroplasty after Memokath endoscopic extraction with Kulkarni-type dorsolateral buccal mucosal graft urethroplasty [14]. This is definitely a discouraging argument for the use of temporary endoprosthesis in patients who wish to receive definitive reconstruction of bulbar urethral stricture. The contraindication for urethroplasty today, i.e. very advanced age, poor baseline condition and elevated comorbidity, is very uncommon and majority of the patients in this population can be managed exclusively by urethral dilatation. In summary, given the durable results of bulbar urethroplasty, arguably, there is no sense to sustain repeated temporary stenting.

27.4 Lessons Learnt for Urethral Reconstruction After Failed Urethral Stents

Angulo et al. have described the results of a multicenter international experience on definitive urethral reconstruction after permanent urethral stent explant, a disease that is fortunately disappearing [10]. Several interesting conclusions reached may help urologic reconstructive surgeons take appropriate decisions to manage these infrequent patients.

This multi-institutional experience confirmed that urethroplasty is a viable option for patients with retained UroLume urethral stents who developed recurrent symptomatic urethral stricture (Fig. 27.10). Results of a definitive reconstruction are encouraging with an overall long-term success rate of 81%. Moreover, urethroplasty has been demonstrated to be a safe procedure in these patients, while carrying a minor complication rate of only 12.7%. Postoperatively, Qmax, postvoid

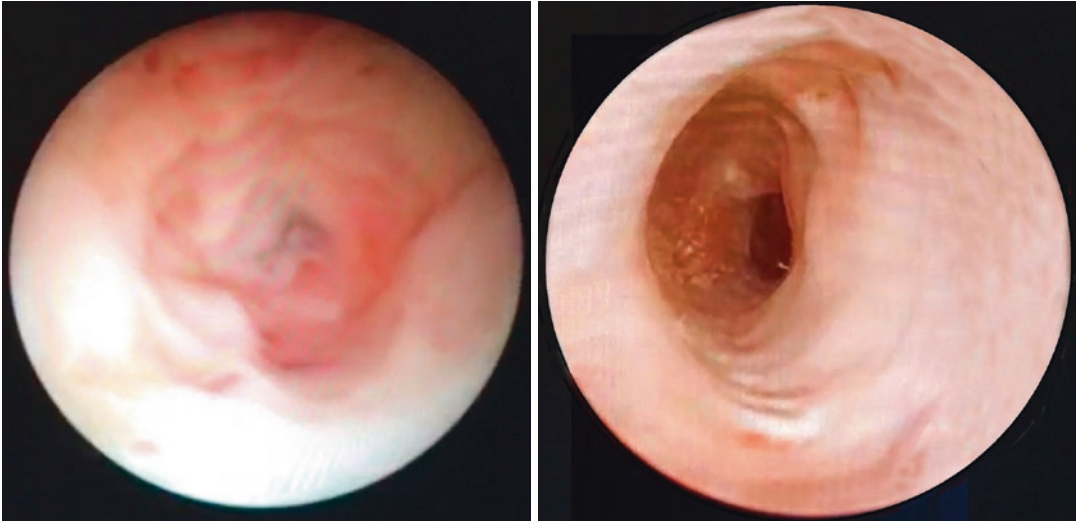


Fig. 27.10 Urethroscopy image before (left) and after (right) Kulkarni operation for UroLume stent removal

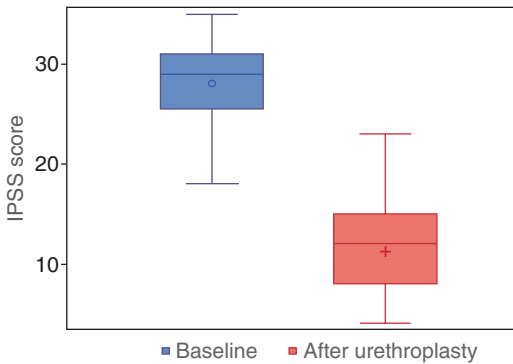


Fig. 27.11 Mean International Prostatic Score of Symptoms (IPSS) for 63 patient treated with urethroplasty after UroLume stent removal (preoperative 28 ± 4.1 and postoperative 11.7 ± 4.2 ; t-student, $p < 0.0001$)

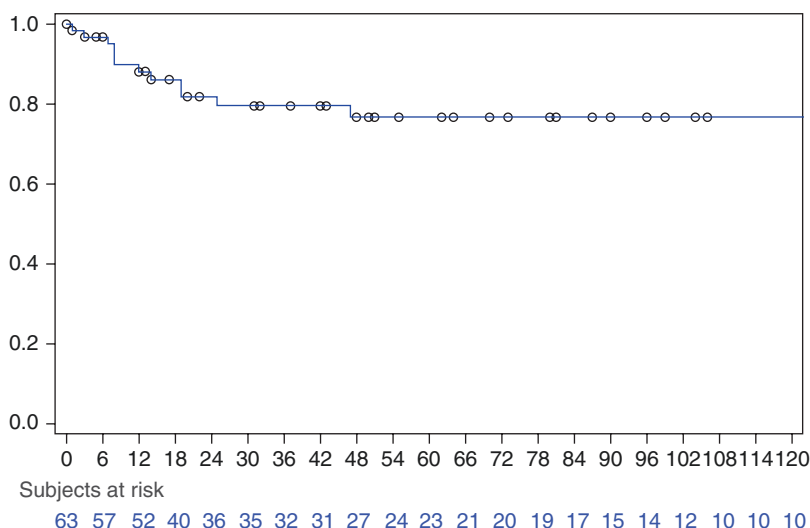
residual, IPSS scores and QoL were shown to be significantly improved compared to baseline (Fig. 27.11).

However, the study had several limitations as it was a retrospective cohort with cases treated during a very long time span by many surgeons using very different techniques. Among the different surgical techniques used non-transecting reconstruction using buccal mucosa applied in a variety of approaches (dorsal onlay, ventral onlay, dorsolateral onlay and ventral onlay plus dorsal inlay grafts) yielded the best results. A complete urethral segment excision and primary anastomo-

sis was the most frequently used technique after UroLume removal. At a median 60 ± 63 months overall success rate was 81%. Analyzed by the type of technique used, the success rates of oral patch urethroplasty, EPA and augmented anastomotic urethroplasty were 96.3%, 85.7% and 80% respectively. Five-year recurrence-free survival for urethroplasty after urethral UroLume stent was 77% (95% C.I. 62.1–86.2) and remained stable for 10-years (Fig. 27.12). Statistically significant difference in favor of oral patch versus the rest of techniques was also demonstrated [10]. In a smaller subset of patients with bulbar urethroplasty after temporary stent retrieval willing a definitive reconstruction non-transecting technique using one-side dissection and dorsolateral buccal mucosa onlay graft also gave excellent results [14].

To conclude, surgical urethral reconstruction after failed urethral stents should be encouraged. Surgical reconstruction for patients with permanent urethral stent that develop re-stricture is always a challenging situation and the mode of explant and the choice of urethroplasty should be individualized. However, urethral preservation with longitudinal section and individual wire extraction followed by buccal mucosal graft urethroplasty should be recommended whenever possible. Similarly, surgical reconstruction for

Fig. 27.12 Kaplan-Meier 77% (95% C.I. 62.1–86.2) recurrence-free survival for 63 patient treated with urethroplasty after UroLume stent removal



patients with temporary stents that have complications and wish a definitive repair are also candidates for bulbar urethroplasty. Patients that elected primary stenting and change their mind do not appear to have worse prognosis than those that elected primary bulbar urethroplasty. Therefore, there is no argument in favor of a temporary stenting instead of urethroplasty, except for those patients in which a primary repair is contraindicated due to frailty or poor life expectancy.

More biocompatible and safe stent devices may be developed in the future. Stents could also be used as platforms for local drug delivery; e.g. drug-eluting stents, and could be a future innovation to prevent restenosis. In the meantime, classical urethral reconstruction seems to be best offered to patients with bulbar strictures, regardless their etiology.

27.5 Conclusions

The permanent urethral stents UroLume was abandoned due to its high rate of long-term failure and complications. Surgical urethral reconstruction after failed permanent urethral stent is therefore becoming a rare situation, but specialized urological reconstructive centers are still managing these complex patients with retained old stents. Long-term success of urethroplasty

after failed urethral stent including removal exceeds 80%. The decision on how to perform stent retrieval and urethral reconstruction can be difficult and management needs to be personalized. However, the most successful technique is buccal mucosal graft onlay urethroplasty after longitudinal urethrotomy of the stented urethra and stricture followed by individual time-by-time removal. When urethral transection and en-bloc segmental resection is performed, excision and primary anastomosis or augmented anastomotic urethroplasty are also viable options for reconstruction. In the worst scenario, lack of urethral patency and diffuse periurethral abscess may preclude immediate reconstruction and definite perineal urethrostomy be the only choice. Temporary urethral thermoexpandable nitinol stenting has very limited indications and is not devoid of encrustation or recurrent stricture. Definitive urethral reconstruction after explant of a temporary Memokath stent in bulbar urethra is feasible and highly successful.

Key Summary Points

- Temporary urethral stenting has very limited indications and definitive urethral reconstruction after explant is feasible and highly successful.

- Surgical urethral reconstruction after failed permanent urethral stent is becoming exceptionally rare, but specialized urological reconstructive centers are still managing these complex patients with retained old stents.
- The decision on how to perform a permanent stent retrieval and urethral reconstruction can be difficult and management needs being decided on an individual basis.
- Long-term success of urethroplasty after UroLume stent removal exceeds 80% with significant improvements in flow rates and functional IPSS, and limited complication rate.
- Several methods of one-stage repair can be successful either using complete full-segment urethral excision or urethral preservation with time-by-time stent extraction.
- Longitudinal urethrotomy along the stented urethra and stricture followed by removal of the wires after and urethral reconstruction with buccal mucosal graft onlay placed dorsolaterally, dorsally or ventrally seems the most successful technique.
- Excision and primary anastomosis or augmented anastomotic urethroplasty are also viable options when urethral transection is performed.
- Two-stage surgery buccal mucosa patch to augment temporary urethroplasty can be needed, even diffuse periurethral abscess with total lack of urethral patency may preclude immediate reconstruction and definite perineal urethrostomy be the only choice.

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Bulbar Urethral Necrosis

28

Pankaj M. Joshi, Devang Desai,
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28.1 Introduction

Pelvic fracture urethral injury (PFUI) occurs in 10% of those who suffer from pelvic fractures [1]. Anastomotic urethroplasty remains the gold standard for treatment of PFUI. Progressive perineal approach is the preferred surgical method and where required transabdominal approach is utilized. Bulbar urethral ischemic necrosis (BUIN) is an iatrogenic entity which results from previous failed PFUI repairs. This entity in the past was referred to as ‘long gap’ or ‘unsalvageable’ after previous failed repairs [2, 3]. Mr. Turner-Warwick had defined spongionecrosis of the bulbar urethra in 1986 [4].

28.2 Anatomical Considerations

Urethra is divided into anterior and posterior urethra. Further anterior urethra is subdivided into penile and bulbar urethra. Bulbar urethra extends from the penoscrotal junction to the membranous urethra.

Bulbar urethra can be divided into distal, mid and proximal portions. The proximal and mid portions are unique as the spongy tissue is more developed in this region. These are

also covered by the bulbospongiosus muscle. The proximal 2/3rd of the muscle is circumferential around the urethra. The distal 1/3rd of bulbospongio-cavernous muscle surrounds the corpus cavernous at the base of the penis [5].

Antegrade blood supply to the urethra is derived from the bulbar arteries and cavernosal arteries. Retrograde blood supply is derived from the dorsal penile artery. The urethra is also supplied laterally by the circumflex vessels. These are all branches of the internal pudendal artery from the anterior division of the internal iliac artery.

28.3 Pathophysiology

BUIN is a loss of long segment or entire bulbar urethra due to vascular insufficiency. Bulbar urethral ischemic stenosis is used for a long near obliterated ischemic stricture of the bulbar urethra.

Turner-Warwick (1986) described the causes for spongionecrosis [4].

1. Over mobilization of distal urethra
2. Hypospadias
3. Extensive spongiofibrosis resulting from multiple previous surgeries.

Anastomotic urethroplasty is the standard of care for PFUI. This involves mobilization of the

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distal urethra. As a result, the lateral circumflex vessels have to be sacrificed. The urethra now depends upon the antegrade and retrograde blood supply. On transection of the urethra through the scar, the bulbourethral vessels, are divided. The urethral blood supply now depends on the retrograde flow via the dorsal penile vessels.

Patients who have poor retrograde flow or where the dorsal penile vessels get damaged during crural separation and inferior pubectomy have a high risk of BUIN [6].

Awareness of this pathophysiology helps prevention of BUIN and its sequelae (Figs. 28.1 and 28.2).



Fig. 28.1 RGU and MCUG suggestive of bulbar urethral stenosis

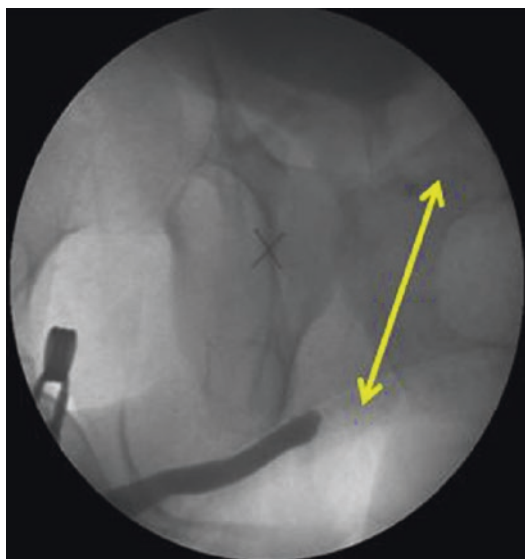


Fig. 28.2 RGU and MCUG depicting bulbar urethral ischemic necrosis (BUIN)

28.4 Discussion

The exact incidence of BUIN is unknown. We have experience of more than 1307 patients who underwent PFUI repair over two decades (1995–2018). Overall success rate for primary cases was 85.4% and for redo cases was 79.13%. One hundred and fifteen cases of BUIN were identified (overall incidence 8.65%). All of these patients had greater than two prior failed attempts at PFUI repair [6, 7]. The numbers are rising recently with we having performed more than 12 flap procedures in last 6 months.

As described earlier the cause for BUIN is poor retrograde blood flow or iatrogenic damage during anastomotic urethroplasty. Preoperative assessment of the erectile function using standardized questionnaires such as IIEF and utilization of penile Doppler ultrasound is recommended by the authors [8, 9].

All patients who underwent PFUI repair at our institution underwent a penile Doppler prior to repair. The parameters evaluated were peak systolic velocity (PSV), end diastolic velocity (EDV) and resistance index for both cavernosal and dorsal penile arteries before and after administration of intracavernosal PGE1. Patients with PSV greater than 35 cm/sec were considered to have a normal arterial response while less than 25 cm/sec signified severe arterial insufficiency.

In patients with severe arterial insufficiency, we recommend penile revascularization procedure, using microvascular anastomosis between inferior epigastric artery and dorsal penile vessels prior to PFUI repair to avoid bulbar urethral ischemia [10]. A high index of suspicion is necessary to diagnose bulbar urethral ischemia. A RUG and MCUG would show a long segment bulbar stenosis or in cases of necrosis there may be absence of depiction of the bulbar urethra.

In established cases of bulbar urethral ischemia, there are limited options for reconstruction. These patients represent a complex subset of patients requiring care in high volume specialized centers. Initial evaluation of type of injury, extent of injury, prior number and type of repairs

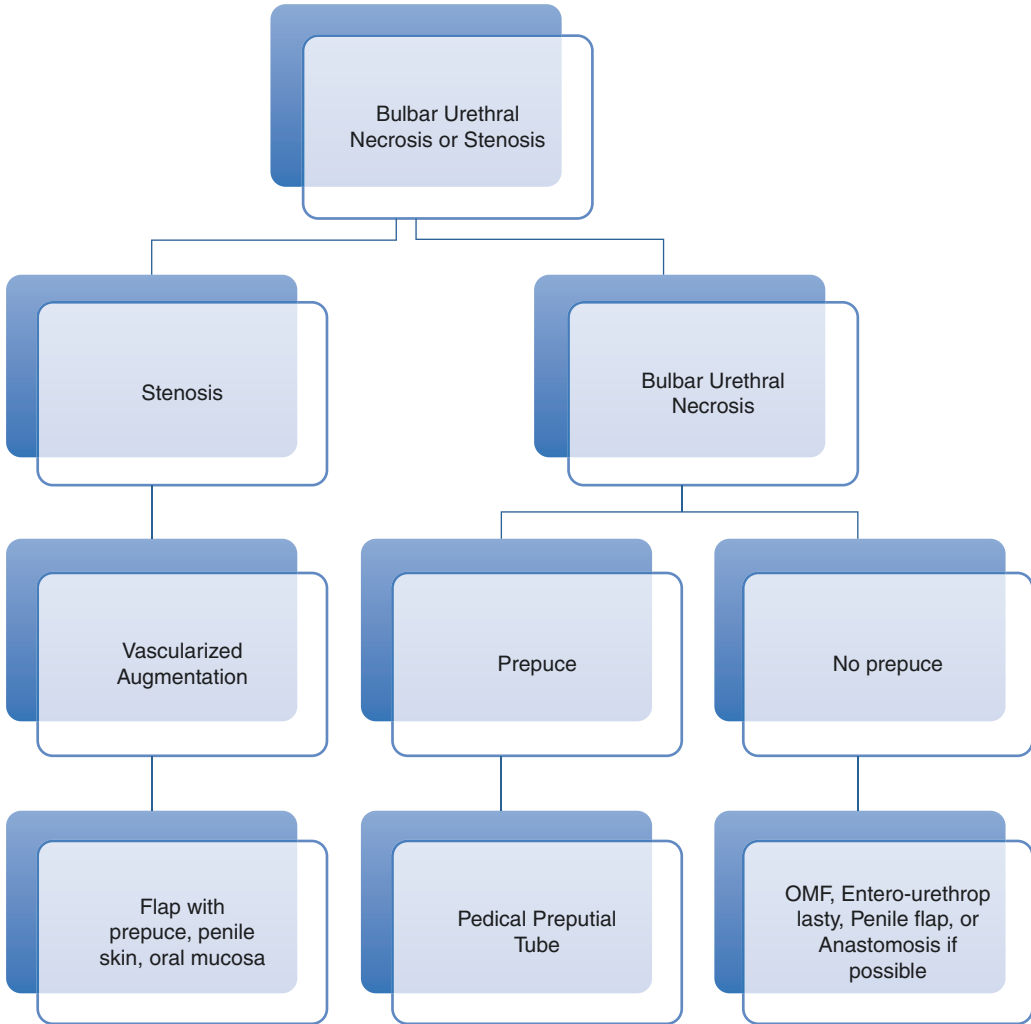


Fig. 28.3 Our algorithm for managing bulbar urethral ischemia

and preoperative assessment of antegrade and retrograde blood flow to the urethra is paramount.

We present our management algorithm (Figs. 28.3 and 28.4) for bulbar urethral ischemia [7].

In patients with bulbar urethral stenosis, urethral augmentation using a buccal graft, or a penile skin flap is utilized. Presence of lumen and the amount of spongiofibrosis determines the need for a vascularized flap as opposed to a buccal mucosal graft.

In cases of BUIN, it's important to note preoperatively whether the patient is circumcised or not. In non-circumcised patients, our

preferred approach, is to use a pedicled preputial tube for repair. Two parallel circumcision incisions are used. The outer circumcision is deep to the skin and superficial to dartos fascia. This dissection is carried forward till the base of penis. The inner circumcision is performed deep to dartos and superficial to the Bucks fascia. The entire prepuce is now mobilised based on the dartos pedicle. This dartos derives its blood supply dorsally. The skin and dartos are split ventrally until penoscrotal junction. and the prepuce is tunnelled into the perineum on a vascularised dartos flap. The inner prepuce is tubularized

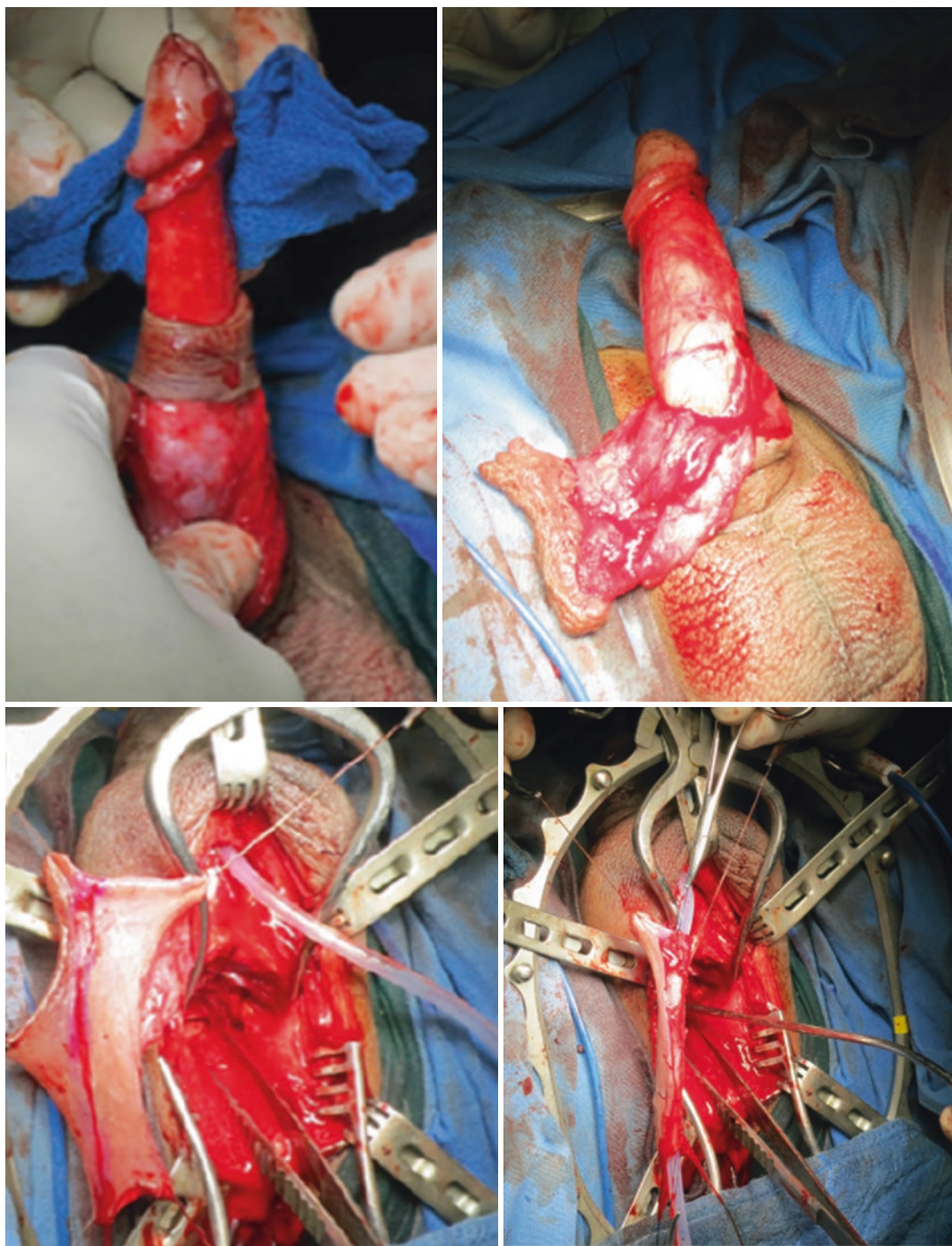


Fig. 28.4 Pedicled preputial tube urethroplasty

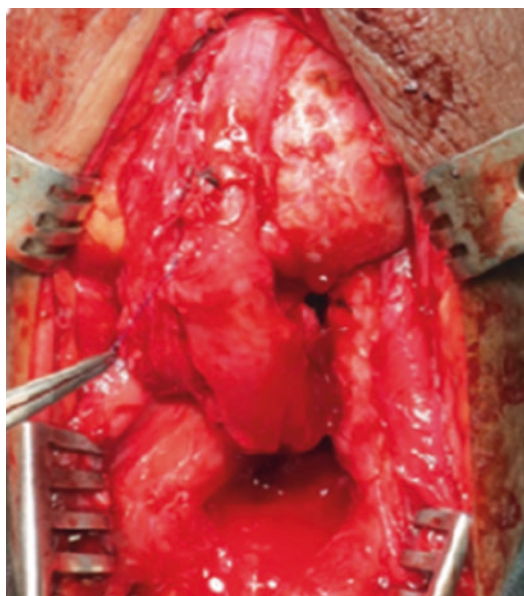


Fig. 28.4 (continued)

and utilized to bridge the long gap between the anterior and posterior urethra. The outer prepuce is sacrificed. This technique can be done using distal penile skin in case where the prepuce is not available [11].

BUIN in patients, who are circumcised, pose a particular challenge. The alternative options for repair include:

1. Oral mucosal flap (OMF) – A 7×3 cm buccal mucosal graft is placed and quilted on dartos at the midline scrotal septum. After a few weeks the graft derives its blood supply from the underlying dartos and can be mobilised on the dartos pedicle, transposed to the perineum and can be used as an onlay flap or tubularised for repair.
2. Scrotal drop back (Turner- Warwick) (Figs. 28.5 and 28.6)

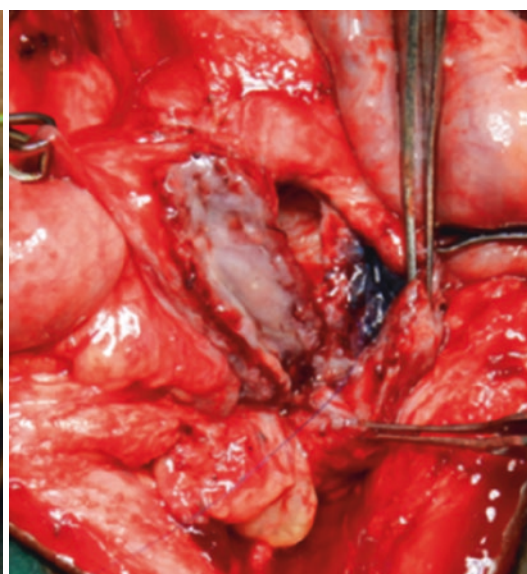


Fig. 28.5 Oral mucosal flap

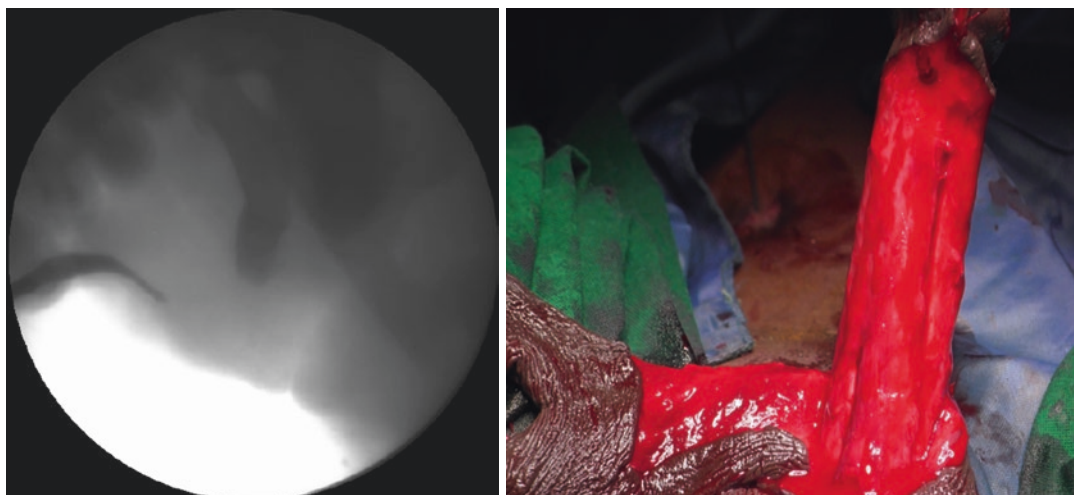


Fig. 28.6 (a) RGU showing long obliterative segment (b) "Q" Fasciocutaneous flap

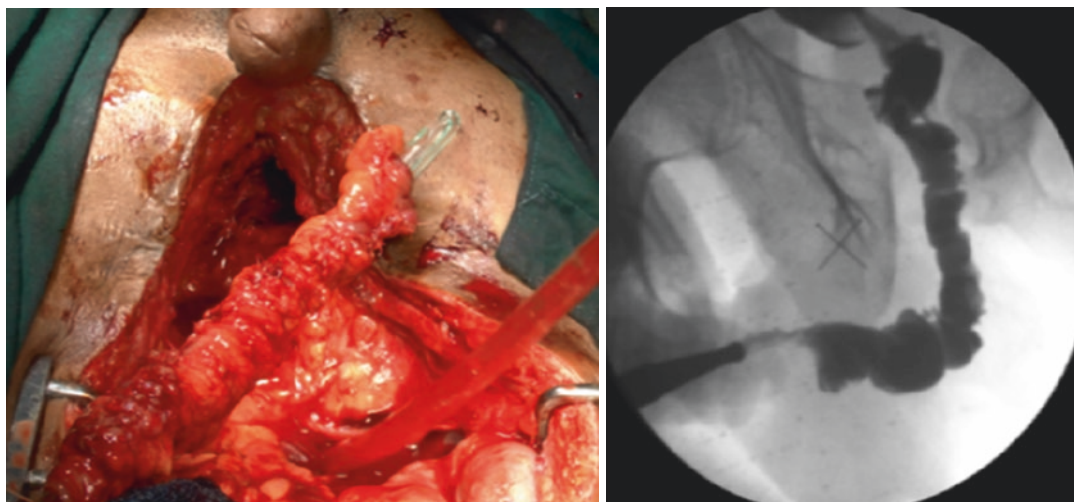


Fig. 28.7 Eneterourethroplasty using sigmoid colon

3. Pedicled penile skin flap (Q flap and McAninch Flap). We have recently been referred patients with very long obliterative ischemic segments which cannot be bridged by pedicled preputial or penile skin flaps. In those cases we have performed the "Q" flap with excellent results (Fig. 28.7)
4. Enterourethroplasty. We have performed two enterourethroplasties as described by Mundy and Andrich using sigmoid colon [12]. Both patients are voiding well without any concerns.
5. Use of buccal mucosa graft (BMG) dorsally and flap ventrally. This can be performed provided inferior pubectomy is not required. An intact corpora cavernosa positioned in the midline is required to quilt the oral graft.
6. Pedicled anterolateral thigh flap for reconstruction for urethral defects [13]
7. Forearm flap with micro vascular anastomosis to inferior epigastric artery [14]
8. Dorsal BMG with ventral BMG on gracilis muscle [14]

Table 28.1 Urethroplasties performed for Bulbar urethral necrosis

Procedure	Number	Success rate
Pedicled preputial tube and Q flap (3 cases)	74	86.4%
Oral mucosal flap	10	58.56%
Pedicled prepuce as onlay augmentation with dorsal BMG	16	89.12%
Scrotal drop back	6	33.33%
Enterourethroplasty	2	100%
Forearm flap with microvascular anastomosis	3	100%
Pedicled anterolateral thigh flap	2	50%
Dorsal BMG with ventral BMG on gracilis muscle transposed to perineum	2	100%
Total	115	76.67%

In our series we have managed 115 cases of BUIN. The following table outlines our usage of the above techniques and results (Table 28.1).

In our experience, the best results have been achieved using a vascularized flap with or without buccal mucosal graft.

28.5 Conclusion

Bulbar urethral ischemic necrosis (BUIN) is a complex subgroup of urethral disease which is better prevented than cured. Reconstructive options are limited and requires a structured approach in a high-volume center with expertise in managing these patients to achieve the best long-term outcomes. These patients remain to be a challenging group where the reconstructive urologist needs to be versatile with various techniques for urethral reconstruction.

Preserving the dorsal penile arteries by performing proper pubectomy, periosteal elevation is important.

No staged surgery can manage this patients.

They are best treated with a single stage pedicled flaps from prepuce or penile skin.

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Use of Fasciocutaneous and Myocutaneous Flaps in Complex Urethral Reconstruction

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29.1 Introduction

The great challenge of urethral reconstructive surgery is to create an adequate caliber lumen with durable success in the presence of complex urethral strictures with associated hostile wound environments. Complex urethral pathology has a variety of phenotypes including strictures with or without associated fistulae, extensive peri-urethral fibrosis, and segmental urethral loss. Furthermore, it may be associated pelvic fractures, perineal trauma, decubiti, radiation damage and re-operative surgery, which may lead to hypovascular and fixed tissues. These account for the most complex and difficult cases confronted by the reconstructive urologist. While these patients represent a minority of cases in a reconstructive urology practice, knowledge and technical proficiency to utilize a variety of fasciocutaneous, myocutaneous and muscular flaps is critical to successful management. The ability to harvest and utilize a variety of flaps requires detailed understanding of the neurovascular and muscular anatomy of the perineum, scrotum, abdominal wall and lower extremity. Often times

flaps are used in combination with oral mucosal grafts (OMG) and skin grafts in single staged and planned multi-staged procedures. Furthermore, as with any surgical practice, proper patient selection for these major procedures is critical. It is important to optimize patients prior to extensive reconstruction, including ensuring adequate diabetes control, smoking cessation, and optimizing nutritional status. This chapter will detail the muscular and neurovascular anatomy of reliable fasciocutaneous, myocutaneous and muscular flaps, surgical decision making, surgical techniques, and outcomes related to the use of these flaps in complex urethral reconstruction.

29.2 Flap Characterization

In order to successfully utilize flaps in reconstructive urologic surgery, it is important to understand the basics including the neurovascular anatomic bases of flap constructs and classification of such flaps. The first flaps used in plastic surgery were what would have been considered random skin flaps, relying on a subdermal vascular plexus [1]. Skin flaps were initially characterized by the way in which they were transferred, its shape and whether the flap was local or distant [1]. Rather than relying on a length to width ratio, Milton determined that the viability of a flap was based on the anatomic basis of its vascular supply and this was furthered by Orticochea who described

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myocutaneous flaps which would allow survival of a larger skin flap relying on vessels perforating the muscle [1, 2]. Ponten then described the inclusion of deep fascia along with a skin flap, which led to longer survival [3].

There are multiple published schemas to classify the various types of skin flaps used in reconstructive surgery. Cormack and Lamberty organized fasciocutaneous flaps into four types based on the origin of circulation to the fascial plexus [1]. Type A is characterized by multiple fascial perforators that are unnamed, akin to a random skin flap. Type B have a large solitary septocutaneous perforator. Type C flaps are composed of multiple segmental septocutaneous branches, which require inclusion of the main source vessel with the flap. Type D is also based on multiple small perforators but is raised as an osteomyofasciocutaneous flap. The Mathes and Nahai Classification is based on the types of deep fascial perforators; Type A is a direct cutaneous flap, whereby the pedicle travels deep to the fascia and then pierces the fascia to supply the skin, Type B is septocutaneous where the pedicle courses within an intermuscular septum, and Type C is a musculocutaneous flap based on a pedicle within the muscle itself [1]. Lastly, Nakajima et al. classified skin flaps into six groups (I-VI) based on perforators of the deep fascia [1]. An angiosome has a specific source artery supplying a three dimensional area of tissue. Perforators were further classified as *direct* or *indirect*, depending on if they traveled through a muscle (indirect) to reach the skin or solely perforated fascia only to reach the skin (direct) [1].

Muscle flaps are versatile and may be used in a variety of scenarios in urologic reconstruction. The Mathes and Nahai classifies muscles into Types I-V based on its vascular supply [1, 4]. Type I has one vascular pedicle; examples include gastrocnemius, rectus femoris and tensor fascia lata. Type II include dominant vascular pedicle(s) and small minor pedicles, this includes the gracilis, biceps femoris, and trapezius muscles. Type III is characterized by two dominant pedicles arising from separate regional arteries, examples include serratus anterior, rectus abdominus, gluteus maximus and semimembranosus. Type IV is

classified by multiple pedicles entering the muscle in segmental distribution, which includes the sartorius and tibialis anterior muscles. Finally, Type V flaps have one dominant vascular pedicle and secondary segmental vascular pedicles, for example pectoralis major, latissimus dorsi and internal oblique. Furthermore, Taylor et al. classified muscle flaps by their mode of motor innervations, which is salient for dynamic muscle transfers, but is beyond the scope of urologic reconstruction [1]. Additionally, flaps may also be classified as conjoined, which includes multiple flap territories with a common physical junction with retained independent vascular supply or chimeric flaps, which has multiple flap territories with independent vascular supply without physical connection except that they are linked by a common source artery [1]. When designing a flap there are six characteristics that must be considered: circulation, constituents, construction, conformation, contiguity and conditioning [1].

29.3 Fasciocutaneous and Myocutaneous Flap Application

29.3.1 Scrotal and Perineal Flaps

In contemporary practice, scrotal and perineal skin are certainly not the primary choices for reconstruction of complex urethral strictures and fistulae; however, they may be useful if no alternative tissues are available and the patient and surgeon accept the high risk of adverse effects when utilizing these flaps. In modern practice, scrotal skin fasciocutaneous flaps are rarely used; however, it is part of the reconstructive armamentarium and thus included for completeness.

Scrotal skin, while popular decades ago, has fallen out of favor for urethral reconstruction because of its elasticity that results in formation of a urethral diverticulum. Scrotal skin fasciocutaneous flaps may be utilized in a variety of situations, where the use of oral mucosa is not desired or unavailable, the presence of abnormal penile skin or unreliable dartos for vascular support in

the case of prior hypospadias repairs, for repair of urethrocuteaneous fistulae and in the salvage setting for strictures or fistulae that have been previously repaired.

A hairless scrotal skin flap or epilated scrotal skin (3 months prior) may be utilized in urethral reconstruction and was first described by Gil-Vernet and Blandy et al. [5–9] Scrotal skin is supplied anteriorly by the deep external pudendal artery and posterolateral from perineal and posterior scrotal arteries originating from the internal pudendal artery [5, 6]. The scrotal fasciocutaneous flap includes the skin, dartos, external spermatic fascia, cremasteric fibers and internal spermatic fascia as described by Gil Vernet. Jordan describes using a lateral scrotal skin based flap whereas Gil Vernet has utilized medial scrotal skin island flaps based on biaxial vasculature and the scrotal septum [5, 6]. These scrotal fasciocutaneous flaps may be conformed in a variety of ways; they may be placed as a skin island with de-epithelialization around the island to be used as dorsal, lateral or ventral onlay [5, 6]. Furthermore, the scrotal flap can also be tubularized to replace a diseased portion of the anterior urethra [5]. The width and length of the fasciocutaneous flap and the size of the skin island can be tailored to the length of the urethral stricture or fistula and the width of the remaining urethral plate. At a mean 39.5 months, Gil-Vernet et al., found an 86% success rate overall, and 81% for tubularized urethroplasty and 80% for panurethral strictures [6]. An important technical consideration when using scrotal fasciocutaneous flap is the precise tailoring of the skin flap to fit the urethrostomy defect and keeping the skin and fascia on stretch when performing the anastomosis to prevent diverticulum formation [5].

29.3.2 Perineal Artery Fasciocutaneous Flap (Singapore Flap)

The perineal artery fasciocutaneous flap is another versatile tissue transfer concept, which can be utilized for reconstruction of the aforementioned

demanding complex bulbar and posterior urethral strictures and/or fistulae. This vascularized flap not only allows for urethral reconstruction, but also allows for perineal skin coverage and can fill in soft tissue defects. The flap is also valuable for perineal and thigh reconstruction following Fournier's Gangrene. The flap has a reliable skin island and is easy to harvest with well-defined borders and associated minimal donor site morbidity. History of radiation for prostate cancer and rectal cancer do not prohibit the use of this flap.

The initial motivation behind the creation of the perineal artery fasciocutaneous flap, was the need for a reliable and sensate flap for vaginal reconstruction for patients with vaginal atresia. The flap was first described by Morton et al. in 1986; however, the neurovascular anatomy and characterization of the flap boundaries were further described by Hagerty et al. 1988 who identified the perineal branch of the internal pudendal artery as the basis of this flap construct [10, 11]. In 1989, Wee and Joseph, two surgeons in Singapore, further defined the boundaries and design of the flap and its neurovascular anatomy [12]. Tzarnas et al., in 1994, were the first to describe the use of the perineal artery fasciocutaneous flap for urethral reconstruction, in a transgender woman with a posterior urethral injury [13]. In 1997, Zinman was the first to publish his experience in using the perineal artery fasciocutaneous flap in male urethral reconstruction [14].

The perineal artery fasciocutaneous flap is an axial fasciocutaneous flap, including the underlying fascia as described by Ponten and would be classified as a Cormack Type B with a single septocutaneous perforator [3]. The flap is a construct of skin, subcutaneous tissues and underlying fascia and can be hinged or used as an island flap with predictable measurements [15]. The fascial support preserves the arborizing vascular network originating from septocutaneous, musculocutaneous or direct cutaneous arteries creating a reliable and predictable vascularized flap [15]. The advantage of the fasciocutaneous flap includes less bulk, ease of flap elevation and are thinner and more pliable, making it useful for urethral reconstruction [15].

29.3.3 Flap Design and Elevation Technique for Onlay Urethroplasty

The perineal artery (Singapore) flap, is a vertically oriented composite of skin, subcutaneous adipose and underlying deep fascia and adductor epimysium [15–17]. The Singapore flap is based on the perineal artery, the second branch of the internal pudendal, which courses lateral to the labia majora in women and scrotum in men. The scrotal branches anastomose with branches of the deep external pudendal, medial circumflex femoral, and anterior branch of the obturator arteries, which augments the flap circulation (Fig. 29.1) [15]. The overlying fascia and epimysium over the adductors are also a component of the flap.

The flap is designed and outlined 6 cm × 15 cm with the proximal base at the level of the mid perineum, approximately 3 cm distal to the anal margin [17] (Fig. 29.2). The perineal artery originates medial to the groin crease and has branches to the skin of the medial thigh and scrotum, which can be identified using a Doppler probe [17]. This sensate flap is innervated by the pudendal and posterior

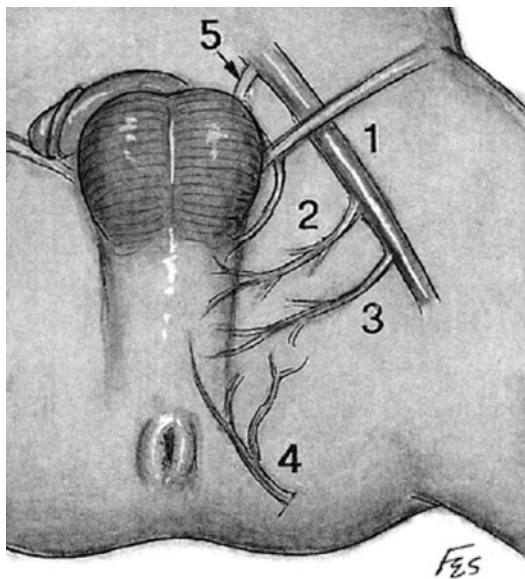


Fig. 29.1 Vascular anatomy supplying perineal artery fasciocutaneous flap. (1) Femoral artery (2) deep external pudendal (3) medial circumflex femoral (4) perineal artery (5) obturator artery (From Zinman [15])

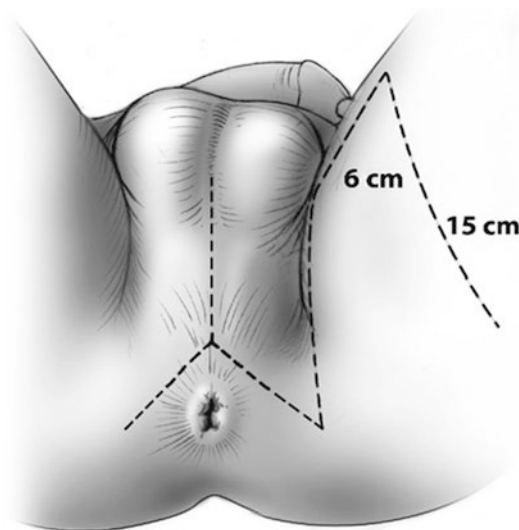


Fig. 29.2 The Singapore flap design and perineal lambda incision (From Zinman LN and Buckley JC [17])

cutaneous nerve of the thigh. A lambda perineal incision is made first to expose the bulbar urethra and the stricture is identified with the aid of a 22F red rubber catheter. Prior to making any urethrotomy, we prefer to inject pure methylene blue which aids in identification of the urethral mucosa. A distal urethrotomy is made and the urethra is opened proximally over the entire extent of the stricture and is extended at least 1–2 cm on each side into healthy urethra (which typically stains very well with methylene blue). Subsequently the urethral lumen is calibrated with bougie a boule to at least 24F. If the edges of the spongiosum are bleeding, the edge of the urethral mucosa may be sutured in running fashion to the tunica of the corpus spongiosum with 4-0 or 5-0 chromic or Vicryl suture. The urethral plate is assessed and the width is measured as with any urethroplasty. The width of the remaining plate determines the width of the flap design to achieve approximately a 3cm urethral plate.

The flap is outlined with the skin on stretch and two parallel incisions are made first to the level of the fascia. The epimysium is raised along with the flap and the fascia is sutured to the dermis to prevent shearing of segmental vessels. The flap is elevated distally, and a distal transverse incision is made and then carried proximally to the base of the flap. Zinman suggests de-epithelializing the

very distal 2–3 mm of the flap to confirm a bleeding dermis to ensure adequate vascularization [15, 17]. The bridge of tissue between the flap and the perineal incision is divided to allow rotation of the flap and obviate the need for tunneling the flap.

A distal transverse island flap is created, approximately 6 cm long. The width is determined by the width of the urethral plate and then 3–4 cm of skin proximal is de-epithelialized leaving an intact dermis to preserve blood supply for the island flap to be used for the urethroplasty (Fig. 29.3). The flap is then rotated inferomedially and the transverse island is anastomosed in standard ventral onlay fashion. It is important to keep the island flap on stretch to prevent bunching of the flap (Fig. 29.4). The apices of the flap are anastomosed in interrupted fashion with 4-0 Vicryl with at least five interrupted sutures and the sides may be closed in a running or interrupted fashion based on surgeon preference. If the urethrotomy is longer than 6 cm, a buccal mucosal graft (BMG) ventral onlay can be used in combination, if there is sufficient distal spongiosum to serve as a vascular bed as described

by Buckley and Zinman [17]. If a BMG is required, the flap should be placed proximally and the BMG composite placed distally (Fig. 29.18). The donor site is then closed by mobilizing and advancing the thigh incision toward the groin. The scrotal bridge is brought laterally and the proximal flap is used to cover the perineum. This is closed in multiple layers (Fig. 29.5). A closed-suction drain is left under

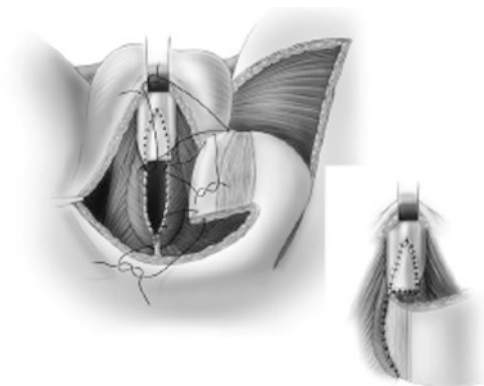


Fig. 29.4 The skin island flap is rotated medially and inferiorly and the skin island is anastomosed to the urethra with running 4-0 absorbable suture. When a longer stricture is encountered and a BMG is used, the flap can be anastomosed to the BMG graft, as shown (From Zinman LN and Buckley JC [17])

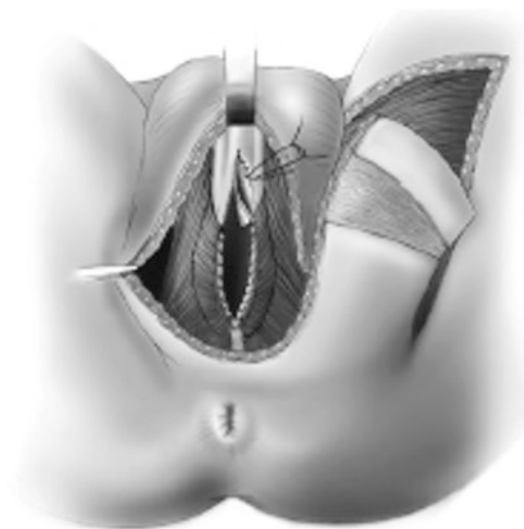


Fig. 29.3 After exposure of the urethra an urethrotomy is shown from the bulbar urethra to the prostatic apex. Here a distally applied BMG is used, although not necessary for strictures 6–8 cm in length, which can be reconstructed with the Singapore flap along. A transverse island flap is outlined distally and a 3 cm wide skin strip is de-epithelialized just proximal to the island leaving a thin layer of dermis intact (From Zinman LN and Buckley JC [17])

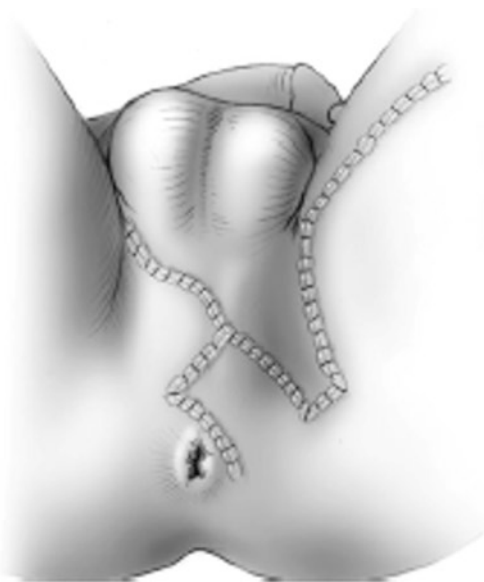


Fig. 29.5 Final appearance of the perineum and donor site (From Zinman LN and Buckley JC [17])

the flap, and a Foley catheter is placed for three to 4 weeks.

29.4 Alternative Flap Designs for Perineal Wound and Urethral Reconstruction

The Singapore flap is versatile and may be utilized in a number of configurations. The flap can be used for the purpose of covering a perineal wound in the same configuration. Additionally, it may be utilized as a cover during complex urethrocutaneous fistula repair.

Long bulbomembranous urethral defects may occur following pelvic fracture urethral injury (PFUI) that cannot be bridged with progressive maneuvers. Tubularization of the Singapore flap is an option in urethral reconstruction of these long segment defects requiring urethral substitution [14, 15]. This technique may also be useful in cases of bulbar urethral necrosis related to compromised urethral vascularization and prior anastomotic urethroplasty. This flap design may be used as a single stage tubularized flap or multi-stage flap design.

The urethra is exposed through a perineal lambda incision, which we find best for very proximal strictures. After urethral mobilization, the obliterated urethral segment is identified distally and transected. The dissection is continued proximally. We find that antegrade flexible cystoscopy is important to delineate the proximal extent of the stricture. The urethra is transected and all fibrotic tissue excised until healthy and supple urethral mucosa is identified. We find that a rongeur is useful to remove fibrotic tissue. Subsequently the two ends can be spatulated and calibrated to 26F–30F distally and proximally. Corporal splitting may be utilized to reduce the distance between the two ends, as well as aiding with proximal visualization. The Singapore flap design is the same as previously described; however, instead of the transverse island a central distal island is created approximately 3–3.5 cm in width and tailored to the length of the defect. The skin surrounding this is de-epithelialized leaving an intact dermis (Fig. 29.6). Zinman

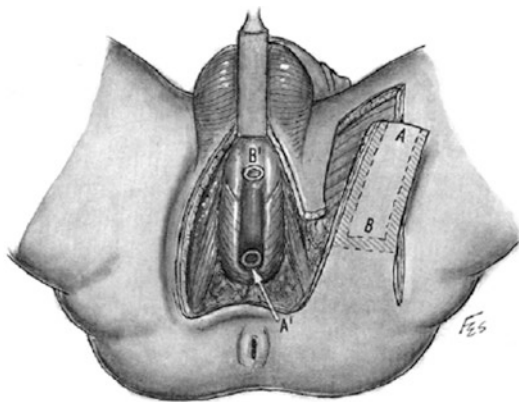


Fig. 29.6 Vertical skin island flap design for tubularized Singapore flap. The distal flap (a) is anastomosed to the proximal urethrotomy and the proximal (b) is anastomosed distally (From Zinman [15])

describes tubularizing the skin island around a 22F Foley; first approximating with interrupted 4-0 Monocryl suture and then using a running 5-0 Monocryl in subcuticular fashion [14, 15]. The distal tubularized flap is then anastomosed to the proximal urethrotomy in interrupted fashion and the proximal aspect is anastomosed to the distal bulbar urethra. The wound is then closed in similar fashion to the onlay flap by mobilizing the edges of the thigh donor site and the proximal flap is used to cover the perineum.

Finally, the flap may be utilized as part of multistage reconstruction and creation of a perineal urethrostomy and the flap is elevated and tailored to the proximal urethrostomy [15]. This would be useful in patients who have undergone multiple prior failed urethroplasties in the setting of adverse host bed conditions including fibrosis, radiation or loss of surrounding perineal/scrotal skin.

The perineal artery fasciocutaneous flap is a versatile flap with reliable vascularization and capable of salvaging the most difficult urethral strictures and segmental loss that are not well suited for BMG or penile or scrotal fasciocutaneous flaps. The benefits of this approach also include minimal donor site morbidity owing to the ability to close the donor site primarily. While the Singapore flap is an important option in urethral reconstruction, in current practice the

gracilis muscle flap in combination with buccal mucosa graft is more commonly utilized in complex urethral stricture management.

29.5 Gracilis Muscle Flap Assisted Urethroplasty

29.5.1 Introduction

The gracilis muscle continues to be a mainstay in the world of reconstructive urology and can be used in a variety of different constructs depending on the clinical scenario. The gracilis muscle is in close proximity to the perineum, groin, genitalia and rectum thus making it a convenient source of healthy vascularized skeletal muscle for genitourinary reconstruction. One of the limitations of the gracilis is that the length is dependent on the length of the leg and typically it can reach the prostatic urethra, but usually cannot reach the bladder to cover rectovesical fistulae [18]. Furthermore, there is little donor site morbidity and little functional consequence in harvesting the gracilis muscle and the remaining adductor muscles adjust and allow normal lower extremity function. The utility of skeletal muscle for the purpose of reconstruction and resolution of wound complications is well established. Muscular flaps can provide coverage of wounds, fill dead space, improve vascularization of wounds, and serve as a host bed for graft take as in the case of BMG for urethral reconstruction [14]. In cases where urethral reconstruction is required and there is significant dead space that is not filled by a single gracilis flap, the contralateral flap may also be utilized.

29.5.2 Gracilis Muscle Flap Anatomy

The gracilis muscle is the most superficial adductor muscle in the thigh and is classified as a Mathes and Nahai Type II flap [1] (Fig. 29.7). The anatomy of the gracilis flap has been well defined. The gracilis is the most medial muscle in the thigh originating as a thin aponeurosis from the medial surface of the pubic symphysis, inferior pubic



Fig. 29.7 The gracilis muscle is exposed here, based on a single dominant pedicle (From Zinman LN and Buckley JC [17])

ramus and ischium and inserts as a long cylindrical tendon into the medial tibial condyle [18, 19]. The muscle is superficial to the adductor magnus and inferior to the adductor longus. The muscle is 24–30 cm in length and 6 cm wide proximally and 4 cm wide distally on average [18]. The vascular supply to the gracilis includes one primary pedicle, the medial circumflex femoral artery, about 10 cm (8–12 cm) from the muscle origin. There are also two minor distal pedicles which are branches of the superficial femoral artery [18–20] (Fig. 29.8). It is innervated by the anterior branch of the obturator nerve and is responsible for thigh adduction and thigh flexion [18]. The nerve enters cephalad and superior to the vascular pedicle and can be dissected for mobilization and enable splitting of the gracilis if needed [18].

29.5.3 Gracilis Muscle Harvest

The patient is positioned in lithotomy with the leg abducted and the knee flexed; however, it is possible to harvest the gracilis in the prone position. We believe it is prudent to prep and drape both lower extremities because a single gracilis may not have sufficient bulk to cover the fistula repair.

A line is drawn from the ipsilateral pubic tubercle to the medial tibial condyle and the skin

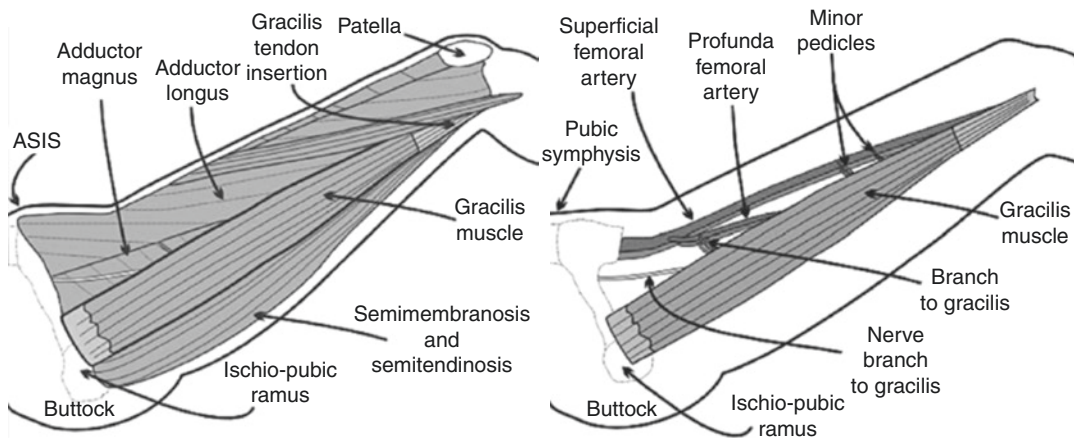


Fig. 29.8 Left panel: The anatomy of the lower extremity and the relationship of the gracilis muscle to the surrounding musculature. Right Panel: The gracilis muscle

vascular supply with the dominant pedicle arising from the profunda femoral artery (From Brandes [18])

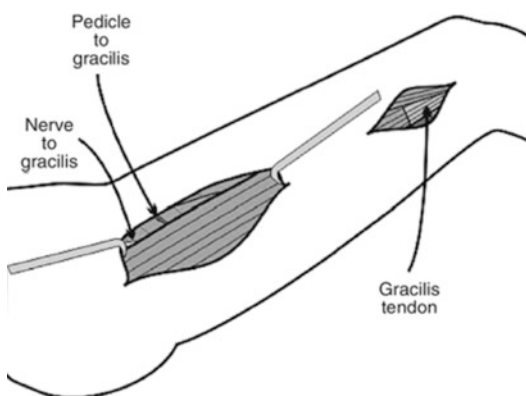


Fig. 29.9 Exposure of the gracilis muscle through an 8 cm incision proximally and a 2 cm counter incision over the gracilis muscle tendon (From Brandes [18])

is marked 10 cm distal to the inguinal crease. Along this line lies the typical location of the primary vascular pedicle (Fig. 29.9). We then measure about three fingerbreadths posterior to our initial line and measure an 8 cm incision starting at the likely site of the vascular pedicle. After the incision is made and dissection is carried through the subcutaneous fat and through the muscular fascia, the gracilis is easily identified. A handheld Doppler can be used to confirm the location of the vascular pedicle, which typically lays 8–10 cm from the ischiopubic ramus entering the deep surface of the muscle. The nerve to the

gracilis can also be identified using a handheld nerve stimulator. By combining bovie electrocautery and blunt finger dissection, the gracilis can be lifted off the adductor magnus and a penrose can be placed around the muscle. Additionally a sponge stick can be used to aid with the distal mobilization of the muscle. We then make a 2 cm small counter incision distally in the same plane, just proximal to the popliteal fossa, over the gracilis tendon. The gracilis tendon is unique because of its long course and insertion into the medial tibial tubercle where it coalesces with the sartorius and semitendinosus muscle tendons as the pes anserinus [18]. The tendon for the semimembranosus is easily distinguished from the gracilis tendon. It is thicker, shorter, and more posterior to the gracilis tendon. If there is confusion, the two incisions can be joined to confirm the gracilis muscle and its tendon before transecting the tendon.

After confirming the identity of the gracilis tendon, it is transected and then pulled through the proximal incision. Bleeding from the avulsed secondary pedicles is typically minor and will vasospasm off and can be controlled with pressure from a compressive wrap. Once the tendon is transected, the muscle can then be rotated 180 degrees toward the perineum. A four finger wide hiatus is then created between the perineum and the leg and the muscle rotated and tunneled into

the perineum. It is important to make the hiatus wide enough and to do this carefully to avoid occlusion or avulsion of the primary vascular pedicle. The leg incisions are closed in multiple layers and we prefer to place a closed suction drain. The leg is wrapped with an ACE bandage.

Alternatively, a short gracilis flap may be utilized when the traditional flap does not have sufficient mobility due to the location of the primary vascular pedicle or the bulk is not sufficient [17]. The short gracilis flap was initially described by Soper et al., and utilized for vulvovaginal reconstruction [21]. Furthermore, Chen et al. applied this short gracilis as a myocutaneous flap for vulvoperineal and inguinal reconstruction [22]. The basis of the short gracilis flap is that the primary vascular pedicle is sacrificed and the muscle is mobilized all the way to its origin at the inferior pubic ramus [21, 22]. The flap is based on the terminal branches of the obturator artery that enter at the muscle origin [21, 22]. The collateral vascular supply must be confirmed first by occluding the primary pedicle and confirming intact circulation with a handheld Doppler probe. This construct allows more muscle bulk to fill in dead space, by using the most proximal part of the gracilis muscle. It also allows for more proximal placement of the flap for higher RUF repairs. It also minimizes the bulky appearance of the medial thigh that is observed with a traditional gracilis flap.

29.5.4 Gracilis Muscle Flap Supported Buccal Mucosal Graft Urethroplasty

BMG has become the favored graft material for urethral reconstruction as initially popularized by Morey and McAninch in 1996 [23]. The gracilis muscle is valuable in situations where there is an unreliable vascular host bed for the graft and adverse tissue and local wound conditions obviating the ability to perform traditional urethral reconstruction techniques. These scenarios require a vascularized graft host bed that can be transferred into the perineum for successful urethral reconstruction. Examples of such situations

include repair of rectourethral fistulae (RUF), urethrocutaneous fistulae after abdominoperineal resection, in cases of long segment pelvic fracture urethral injuries, bulbar necrosis, large urethral diverticulae, and in failed prior urethral reconstruction.

The patient is placed in dorsal lithotomy with Allen Yellofins Stirrups, and both lower extremities prepped beyond the knee. As described by Zinman and Buckley, the sequence of reconstruction is first to expose and mobilize the urethra as necessary depending on the particular scenario [17]. For proximal bulbar and posterior urethral pathology, we prefer a lambda incision to optimize urethral exposure, if repairing a proximal RUF we prefer a classic inverted U incision. Depending on the situation, stricture, fistulae, or both, the distal extent of the urethral pathology is identified with cystoscopy or a 22F red rubber catheter, the proximal extent can be identified with antegrade cystoscopy via suprapubic tube site or using a small Fogarty balloon. If dealing with a fistula, we prefer to place a wire and a small catheter across the fistula through the rectum to aid with identification of the fistula. After the urethral pathology has been delineated, a ventral urethrotomy is made and extended at least 1 cm into healthy urethra, in the case of RUF, the fistula is exposed and the margins are debrided until supple margins are achieved. Palmer et al. published on their experience with ventral BMG and gracilis muscle flap urethroplasty, with 80% success at a mean follow up of 40 months [24].

For small RUF the urethra and rectum can be closed primarily, with the gracilis flap used to interpose between the repairs and fill dead space and secured into the perineum. However, with long strictures and/or fistulae, BMG is the ideal graft material to be supported by a gracilis flap in this scenario (Fig. 29.10). After urethral plate assessment and stricture length assessment, and/or size of fistula defect, the BMG graft can be harvested. BMG graft size is tailored to size to reconstruct the urethra. We prefer to initially suture and fix the BMG to the muscle and then anastomose it to the urethra, rather than applying the BMG to the urethra first and then trying to fix the gracilis to the BMG. This can be done to place

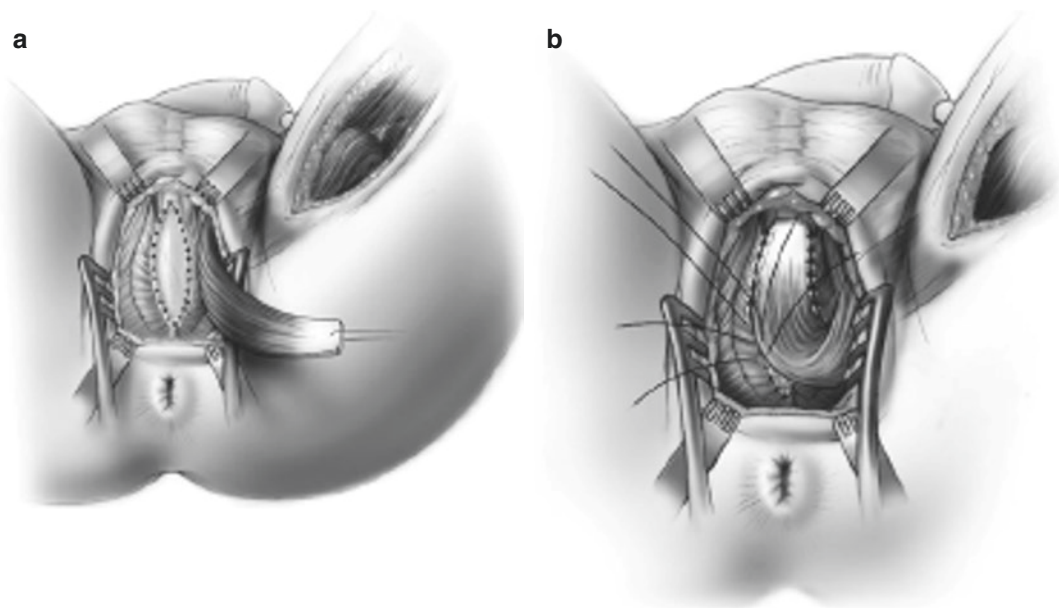


Fig. 29.10 (a) BMG has been applied to the urethrotomy and/or fistula site and the gracilis has been detached from its tendinous insertion and rotated 180 degrees and tunneled into

the perineum. (b) The gracilis is secured to the BMG and periurethral tissue to fix the muscle in place and to provide support for the BMG (From Zinman LN and Buckley JC [17])

the BMG both ventrally or dorsally, depending on the scenario. Kaufman et al. have published on their experience with RUF repair with BMG and muscle flaps, with 98% successful RUF closure for non-radiated cases and 86% for radiation associated RUF repairs [25].

However, there are several situations where a dorsally applied gracilis supported BMG may be beneficial [17]. In patients with spinal cord injury and dorsal urethral erosion from pressure against the pubic arch and/or in cases with perineal central decubitus, the dorsally placed flap is preferred [17]. In the case of a dorsally placed flap, the bulbar urethra is completely mobilized and rotated to apply the BMG/flap composite onto a dorsal urethrotomy (Fig. 29.11). The urethroplasty is completed with interrupted 4-0 or 5-0 PDS or Vicryl sutures and the muscle edges are fixed with interrupted sutures. In the case of a perineal decubitus and urethral fistula, a Singapore flap can then be utilized to cover the perineum [17].

Alternatively, one may “prefabricate” a skin graft or BMG to an exteriorized gracilis muscle prior to transferring it to the perineum for reconstruction (Fig. 29.12). This multi-stage approach is

avored in cases where traditional techniques are not possible due to associated periurethral fibrosis, hypovascular and/or radiation damaged tissues, as well as in salvage cases with prior failed reconstruction. This concept was initially described by Enol in 1976 [26]. The utility of this technique is to ensure adequate graft take without any uncertainty prior to urethral reconstruction. The additional benefits of this approach with the use of a skin graft and BMG is that it obviates the need to use a large bulky myofasciocutaneous flap.

The prefabrication technique involves exteriorizing a 10–12 cm segment of the distal gracilis muscle. The muscle is sutured to the dermis of the skin edge. A hairless full thickness skin graft or BMG is fixed to the muscle belly at the edges and quilted, followed by placement of a tie-over bolster dressing which is left in place for 5 days. Once the graft appears mature and supple and the incision sites are well healed, then the second stage may be undertaken [27]. During the second stage, the urethra is exposed as previously described and a ventral urethrotomy is made to extend into healthy urethral mucosa. Once the urethral plate is assessed and the length of graft material is

Fig. 29.11 Here the BMG is applied to a dorsal urethrotomy and the gracilis is rotated to support the BMG dorsally (From Zinman LN and Buckley JC [17])

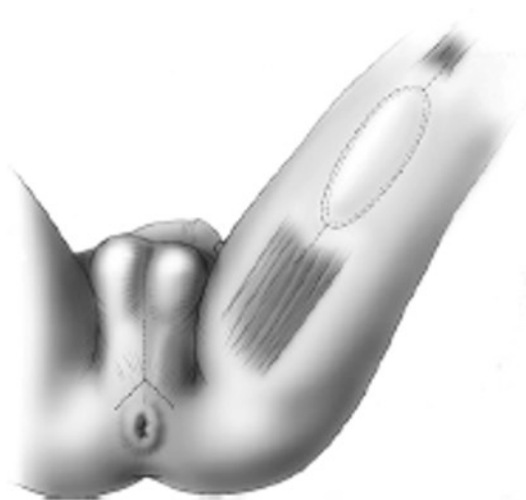
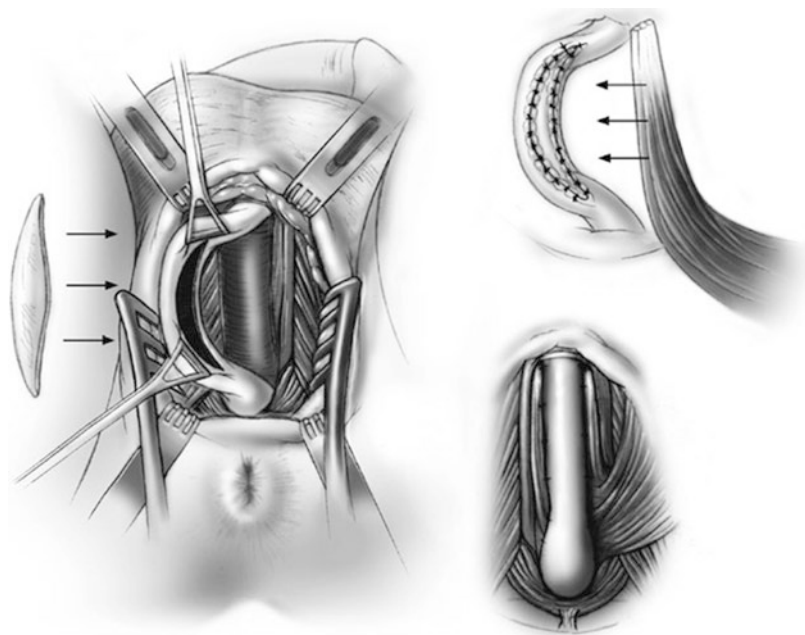


Fig. 29.12 After the gracilis is exteriorized a BMG or skin graft is applied to the muscle. After graft take is confirmed, the prefabricated flap design is used to isolate and elevate the flap for use in urethral reconstruction (From Zinman LN and Buckley JC [17])

determined, the attention is turned towards the now prefabricated gracilis flap (Fig. 29.13).

The composite prefabricated gracilis flap is then prepared. A circumferential incision is made around the site of the skin graft/BMG including a 3 mm margin of thigh skin [17]. The incision is extended

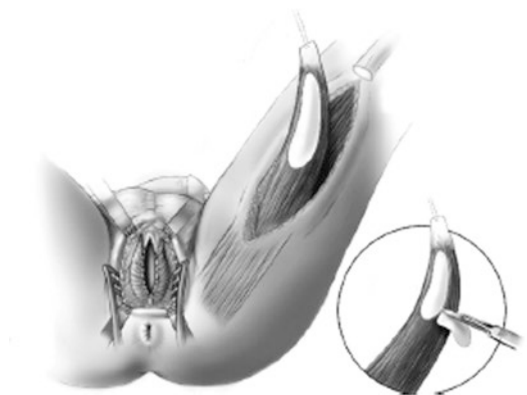


Fig. 29.13 The BMG/Skin Graft and Gracilis composite flat is elevated and tailored to the urethrotomy defect and mobilized into the perineum (From Zinman LN and Buckley JC [17])

to expose the gracilis muscle proximally and the tendon distally. The skin graft/BMG is then tailored appropriately to complete the urethral reconstruction. Zinman notes that it is important to keep a 2–3 mm margin of redundancy, after which the tendon is transected [27]. The gracilis is mobilized as previously described and is rotated and transferred through a hiatus into the perineum for completion of the urethral anastomosis (Fig. 29.14).

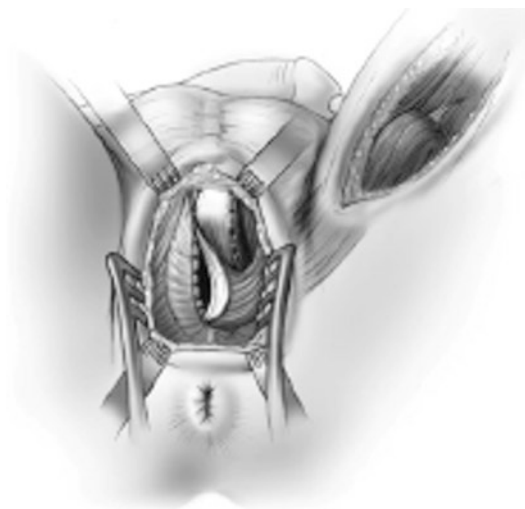


Fig. 29.14 The gracilis and BMG/Skin graft composite flap is anastomosed to the urethra to complete the reconstruction (From Zinman LN and Buckley JC [17])

29.5.5 Gracilis Myofasciocutaneous Flap

The gracilis myofasciocutaneous flap can be utilized to cover perineal decubiti and urethral fistulae associated with radiation, inflammatory bowel disease, Fournier's gangrene, or prior abdominopelvic resection. Prior to the technique described by Whetzel and Lechtman, this flap was associated with partial or total flap necrosis in 27% and 9% of cases respectively [28]. In cadaveric dissections they recognized that the vascular supply to this composite flap included the medial femoral circumflex artery, as well as fasciocutaneous perforators from the superficial femoral artery, which creates an axially oriented fascial system supplying the overlying skin [28]. Thus, it was important that the flap harvest included the underlying surrounding fascia overlying the adductor longus, Sartorius and portions of the vastus medialis, adductor magnus and semitendinosus [28]. This technique resulted in no cases of flap loss or necrosis [28] (Figs. 29.15 and 29.16).

Buckley and Zinman, described their technique in harvesting the gracilis myocutaneous flap [17]. The size of the cutaneous portion of the flap is determined by the size and/or depth of the perineal defect needing to be filled and covered. Whetzel and Lechtman found that the skin paddle design

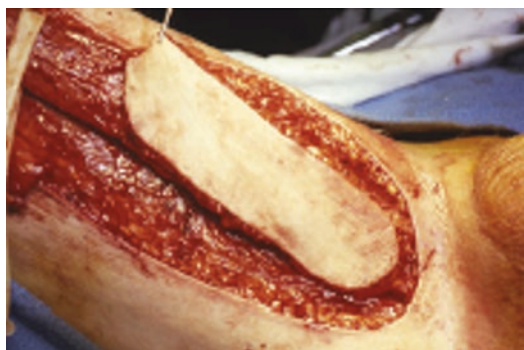


Fig. 29.15 Elevation and mobilization of the gracilis myofasciocutaneous flap (From Zinman LN and Buckley JC [17])

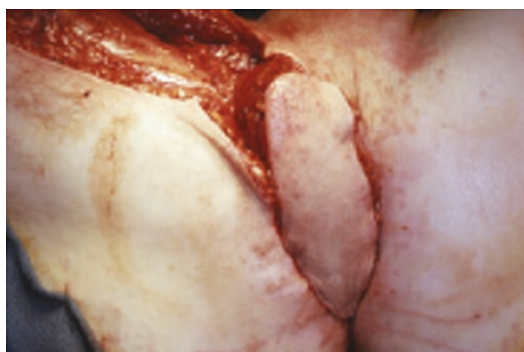


Fig. 29.16 Transfer of the gracilis myofasciocutaneous flap into the perineal wound for coverage of the complex perineal wound (From Zinman LN and Buckley JC [17])

is between 6 and 12 cm, but typically around 8–10 cm wide and can be between 18 and 30 cm long, but typically limited to 20 cm [17, 28]. The skin paddle is outlined on the unflexed thigh in an oval shape with the center over the anterior edge of the proximal two-thirds or middle third of the gracilis muscle (Fig. 29.16). The anterior flap is dissected to the deep fascia with an outward bevel to include more fascia to maintain cutaneous blood supply [28]. The fascia is incised circumferentially and dissected away from the underlying muscles to be included in the flap, and the fascia is sutured to the skin to avoid shearing that may disrupt the vascular network supplying the flap [17]. The distal gracilis tendon is transected and a traction suture is placed on the tendon to aid in orienting the flap. However, a short gracilis construct can be utilized in this setting. The flap is then rotated on the pedicle to the perineal wound through a subcutaneous tunnel or by dividing the skin to

bring the flap into place. The thigh and perineal wounds are then closed and a closed suction drain is left in place and the leg is wrapped with an ACE bandage. Buckley and Zinman prefer 72 hours of bedrest and 7 days of prophylactic anticoagulation with subcutaneous heparin [17].

29.5.6 Gluteus Maximus Muscle Flap

The gluteus maximus flap is uncommonly utilized but is a valuable and reliable muscle flap which can fill in large amounts of dead space and provide a vascularized bed for lower urinary tract

reconstruction for the management of recalcitrant fistulae and strictures. Applications of the gluteus maximus flap include a posterior approach for high rectovesical fistulae, prostatic fistulae, prostatic fistulae, and in complex proximal urethral strictures that may be related to treatments for prostate and colorectal malignancies, inflammatory bowel disease, trauma, and perineal decubiti, amongst other etiologies [17]. Typically these types of pathology result in fibrotic and fixed tissues and thus require healthy vascularized tissue to enable repair and fill dead space when necessary and the gluteus maximus serves this purpose well (Fig. 29.17).

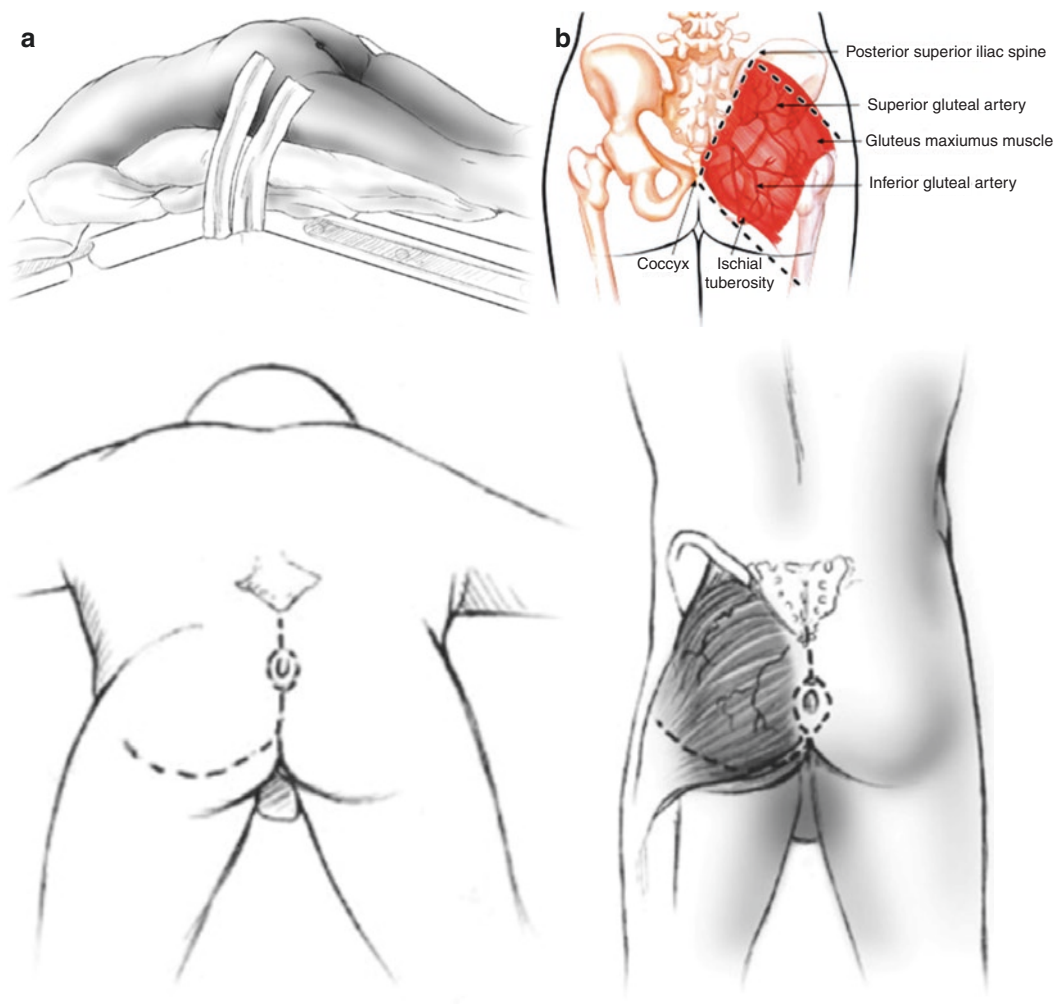


Fig. 29.17 (a) With the patient in the prone position and properly padded. The incision is made from the coccyx to the scrotum in the midline of the perineum. The incision can be extended laterally in a curvilinear

fashion to expose the inferior segment of the gluteus maximus. (b) The anatomic landmarks for the gluteus maximus flap (From Zinman LN and Buckley JC [17])

The gluteus maximus is a quadrilateral muscle that is approximately 24×24 cm and is classified as a Type III flap [1, 17]. The origin of the gluteus maximus is the gluteal surface of the ilium, lumbar fascia, sacrum, and sacrotuberous ligament. It inserts into the gluteal tuberosity of the femur and iliotibial tract. The two primary pedicles are the superior and inferior gluteal arteries, which are branches of the internal iliac arteries [17]. Moreover, there are two minor pedicles, a perforator arising from the profunda femoris artery and intramuscular branches of the lateral circumflex femoral artery [17]. The superior and inferior gluteal arteries are typically 4 cm from the midline and emanates above and below the piriformis [17]. The muscle is innervated by the inferior gluteal nerve (L5-S1) and functions to externally rotate and extend the hip, which is important for running, climbing and jumping [15]. The inferior gluteal nerve passes through the sciatic foramen along with the inferior gluteal artery, medial to the sciatic nerve and enters the muscle posteriorly [17]. Typically, the gluteus maximus flap utilizes the inferior half of the muscle, leaving the superior half intact, for perineal and vaginal reconstruction. The inferior segment can be mobilized and rotated along the axis of the edge of the sacrum.

In cases involving a fistula, we prefer to first do cystourethroscopy and place a guide wire or 5F ureteral catheter through the fistula tract. Afterwards, the patient is placed in the prone position, ensuring proper padding of the extremities and chest, and the patient is flexed at the waist and the legs abducted. The operative landmarks, including the lateral edge of the sacrum and the greater trochanter and the origin and insertion of the gluteus maximus, are then outlined. A wide fish-mouth incision is made around the fistula tract and extended vertically above and below the fistula site between the scrotum and coccyx (Figs. 29.18 and 29.19) [17]. This incision is then carried in a curvilinear fashion laterally in the inferior gluteal crease to expose the muscle. The midline intergluteal incision is then dissected superiorly under the coccyx and down

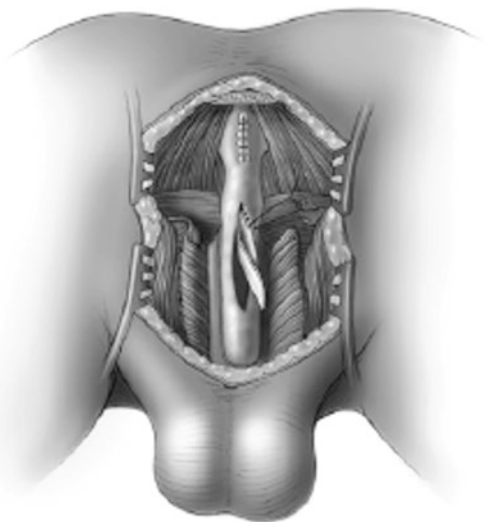


Fig. 29.18 The proximal urethra and prostate are exposed here and the fistula tract is excised and a BMG can be applied to the site of a stricture/fistula (From Zinman LN and Buckley JC [17])



Fig. 29.19 Elevation of the inferior segment of the gluteus maximus where the muscle has been split in the middle based on the inferior gluteal pedicle and the flap is elevated and dissected to the origin so that it can be rotated without tension (From Zinman LN and Buckley JC [17])

the pelvic sidewall, which can be carried further along the sacrum for more cephalad exposure [17]. Once the urethra is exposed, the fibrotic tissues removed and the edges of the urethra appear supple, the fistula is closed and/or repaired with BMG placed ventrally with later use of the gluteal muscle flap for vascular support. Furthermore, if proximal exposure of the prostate and/or bladder is required, the lower sacrum and coccyx may be resected. If the sacrum needs to be resected, it may be useful to have Orthopedic Oncology assistance.

Buckley and Zinman describe the flap elevation by first elevating the inferior portion of the gluteus maximus and then splitting the muscle. The inferior half is separated from the insertion into the iliotibial tract and gluteal tuberosity and the muscle is mobilized from lateral to medial [17]. It is important to use a handheld Doppler to identify and protect the inferior gluteal artery. If more mobilization is needed the muscle can be mobilized off the sacrum. It is important to remain cognizant of the sciatic nerve which is deep to the gluteus maximus below the piriformis muscle. Once the surrounding structures are identified and the pedicle is isolated the muscle can be split. Typically, a 10 × 20 cm flap can be elevated based on the inferior gluteal pedicle [17]. The flap can then be rotated into the perineal defect and fixed to the tissue surrounding the urethra, prostate and/or bladder and can be quilted onto BMG when necessary (Fig. 29.20). Once the flap is secured, the donor site can be closed by mobilizing the skin edges and closed primarily. A skin graft is rarely required.

The benefits of the gluteus maximus flap is that the muscle has large bulk and is available for use in the majority of people. The scar is concealed and harvesting typically has little functional consequence if only the inferior gluteal segment is utilized. Any function deficits like climbing stairs are typically short lived and returns with physical therapy. However, the main potential risks include thigh numbness due to damage of the posterior cutaneous nerve and risk of a seroma at the donor site.

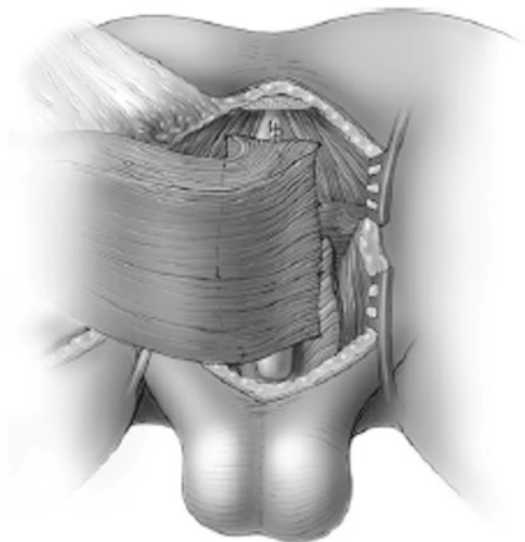


Fig. 29.20 The distal gluteus maximus flap is rotated and advanced into the perineal wound to fill any dead space and provide support for the BMG (From Zinman LN and Buckley JC [17])

29.5.7 Rectus Abdominis Muscular Flap and Vertical Skin Island Flap

Mathews and Bostwick initially described the utility of the rectus abdominis muscle flap in 1977 for abdominal wall reconstruction [29]. In genitourinary reconstruction it may be utilized for pelvic reconstruction, including management of prostatosymphiseal fistulas, as described by Kaufman et al. [30]

The origin of the rectus abdominis muscle is at the pubic crest and anterosuperior pubic symphysis and there are three tendinous fascicles that insert to the fifth, sixth and seventh costal cartilages [17]. Additionally, there are tendinous insertions that are adherent to the anterior rectus sheath. The anterior and posterior laminae fuse at the midline to form the linea alba and also fuse laterally [17]. The blood supply is from the inferior and superior deep epigastric arteries and is classified as a Type III flap [1, 17]. The inferior deep epigastric artery is a branch of the external iliac artery and travels anterior to the transversalis fascia. It enters the muscle

laterally, about 5 cm above the pubis and then anastomoses with the superior deep epigastric artery above the umbilicus. There are four different vascular configurations supplying the rectus abdominis (Fig. 29.21). The muscle, on average, is 25 × 6 cm depending on body habitus and the

inferior pedicle is on the lateral aspect of the muscle about 5 cm from the pubis [17]. When the flap is based on the inferior deep epigastric pedicle the flap rotates at the level of the pubis. The muscle is mobilized off the pubis and the pedicle can be mobilized to extend the advance-

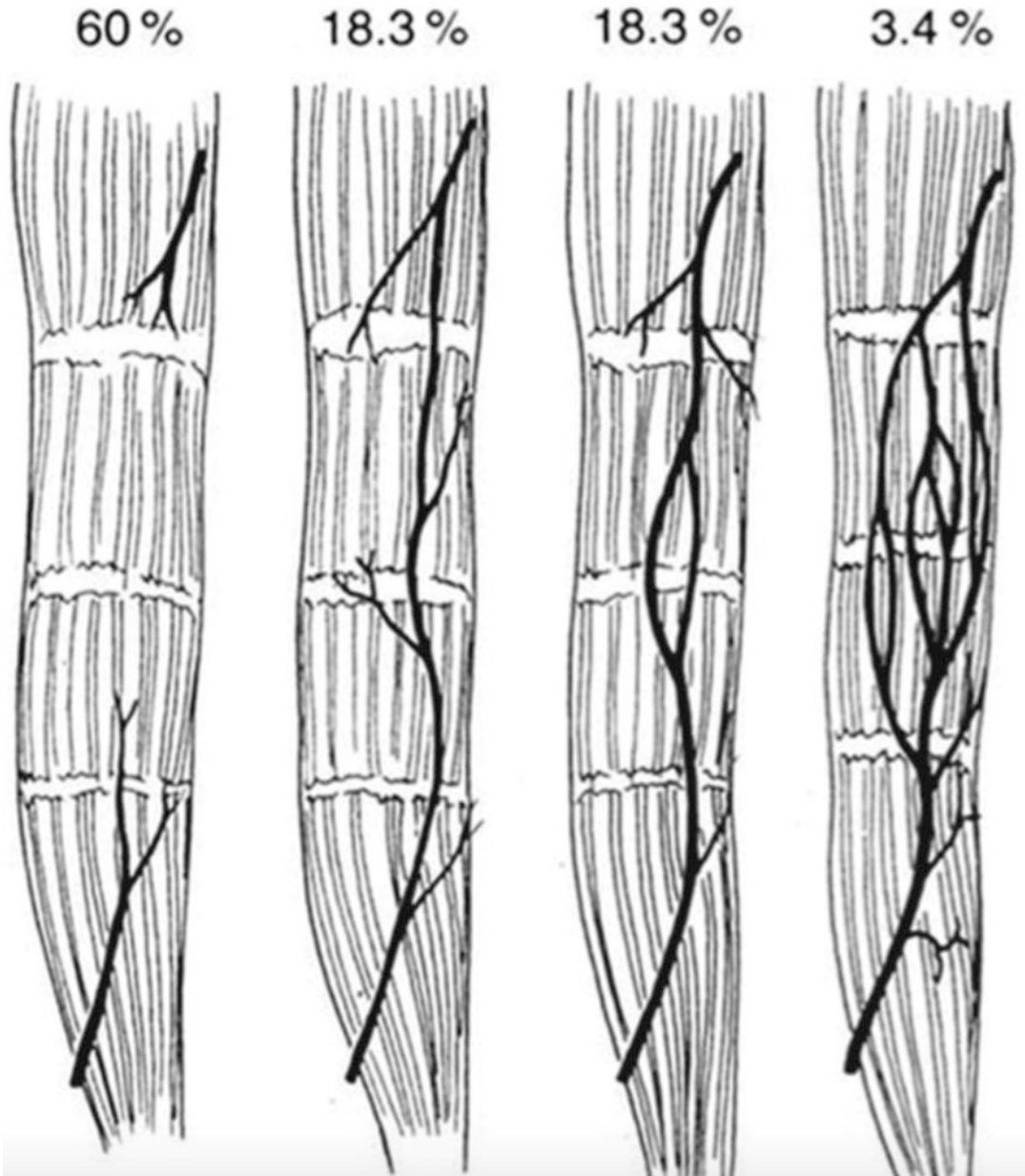


Fig. 29.21 The four patterns of vascular supply for the rectus abdominis flap which is supplied by the superior and inferior deep epigastric arteries (From Zinman LN and Buckley JC [17])

ment of the flap. The muscle belly is divided off the costal margin. The flap can be rotated anteriorly or posteriorly depending on how the flap will be utilized. In the case of a prostatesymphysal fistula, the rectus abdominis is rotated into the pelvis and used to cover the fistula and pubic symphysis after debridement of the pubic symphysis [30].

Alternatively, a vertical rectus abdominus myocutaneous flap (VRAM) can be utilized for coverage of wounds involving the groin and perineum. There are multiple perforators that supply the skin island, with the largest density around the umbilicus. The limits of the skin island flap are 6–8 cm in width and can be 14–21 cm long depending on the patient characteristics. The flap is elevated using a paramedian incision into the rectus sheath which is dissected and preserved as part of the flap. It is important to preserve as much sheath as possible while enabling primary closure. Buckley and Zinman describe placing multiple 3-0 Vicryl sutures between the skin, anterior rectus sheath and the muscle to prevent shearing of the perforators [17]. The posterior sheath is separated and then the muscle is divided in the inferior-based flap and advanced into the wound for coverage.

29.6 Conclusions

This chapter details the surgical decision making and management of complex urethral pathology utilizing fasciocutaneous and myocutaneous flaps. The flaps described herein are versatile and can be utilized in combination with OMG and be used in a variety of scenarios such as urethral trauma, radiation damage, decubiti, and in select cases of re-operative urethroplasty. It is important for the reconstructive urologist, to have a good understanding of the indications for utilizing these flaps and the neurovascular anatomic basis of the flap design, as well as the technical skill to harvest these flaps. Fasciocutaneous and myocutaneous flaps remain an essential tool in the surgical armamentarium for the reconstructive urologist.

Key Summary Points

- Complex Urethral pathology may be characterized by strictures, fistulae, extensive periurethral fibrosis, and hostile local wound environments or a combination thereof
- There are a variety of flap classification schema largely based on the vascular supply of the flaps
- Scrotal fasciocutaneous flaps are rarely utilized today for urethral reconstruction.
- Perineal Artery Fasciocutaneous flaps may be used not only for urethral reconstruction but also for perineal skin coverage such as cases of Fournier's Gangrene.
- Muscular and myocutaneous flaps are versatile and can be used in a variety of scenarios such as filling in dead space, improve vascularization of wounds, serve as a host bed for OMG, and provide wound coverage.
- The gracilis flap can be used in variety of constructs for complex urethral reconstruction including rectourethral fistulae, urethrocutaneous fistulae and in cases of urethral loss. It can also be utilized as a myofasciocutaneous flap to provide coverage for perineal wounds.
- The gluteus maximus flap is an option for patients with recalcitrant rectovesical, rectourethral fistulae and urethrocutaneous fistulae related to prostate cancer and colorectal cancer treatments, inflammatory bowel disease and trauma.
- Rectus Abdominis flap and vertical rectus abdominis myocutaneous flap may be used for reconstruction of prostatesymphysal fistulae or as perineal/groin wound coverage.

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Use of Bowel for Urethral Reconstruction

30

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30.1 Introduction

There has been precedence in using bowel segment to substitute affected urinary system structures. Ileum has previously been used to replace the ureter in long ureteric strictures that are not salvageable using conventional treatment [1].

Urethral reconstruction in patients with several previously failed attempts becomes particularly demanding. This subgroup of patients include failed urethral repairs resulting in bulbar urethral necrosis, such as after multiple failed pelvic fracture urethral injuries.

30.2 Discussion

Patients with unsalvageable anterior urethral strictures can be dealt with perineal urethrostomy. Dilatation, self catheterisation remain viable options after failed multiple urethroplasties. However when it comes to failed posterior urethroplasty, such options exist rarely when there is long segment loss of urethral continuity. Such patients are categorised as bulbar urethral necrosis. Use of penile skin flaps give long term solutions. Some patients may not have healthy flap tissues or it may not be long enough to bridge the gap. An option in

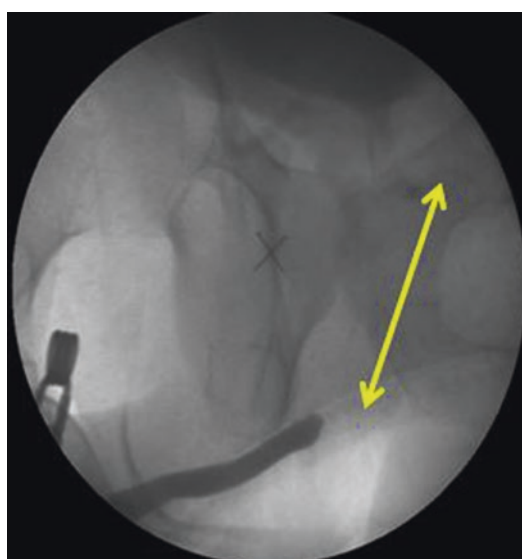


Fig. 30.1 RGU and MCUG depicting bulbar urethral ischemic necrosis (BUIN)

such patients for repair is the substitution using a bowel segment (Fig. 30.1).

Several publications in the literature evaluate the use of bowel segments both in experimental and clinical studies. These studies describe the use of free colonic mucosa and pedicled bowel segments including – stomach, ileum, right colon, transverse colon and sigmoid colon. The choice of bowel segment depends upon several factors – length and site of urethral substitution, previous bowel surgery, bowel disease and blood supply to the bowel [2–6].

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Patient selection for these procedures is of paramount importance. The key is to evaluate which patient would benefit from urethral substitution using a bowel segment. The next challenge is to find the best suited bowel segment for the reconstruction. Usually the bowel segment with pedicle closest to the prostate is suitable. The preferred choice is the use of sigmoid colon. Patients need to be admitted a day prior to urethroplasty. Bowel preparation is given and may include enema. Preoperative intravenous prophylactic antibiotics are started. Urethroplasty usually starts with a perineal incision and dissection. The healthy end of anterior urethra is identified. Crural separation and inferior pubectomy is performed as and when necessary. In our experience, these patients often have a high bladder neck requiring a transpubic approach. This is usually performed with an infraumbilical midline incision. The initial dissection is retroperitoneal. Posterior pubectomy is performed and scar tissue excised. The posterior urethra is incised on a bougie passed from the SPC tract. This avoids opening the bladder. Once the posterior urethra is adequately freed from scar tissue, assessment of length of gap is made. The sigmoid colon is mobilised on its mesentery. The lower portion of sigmoid colon needs to be sacrificed and the upper part is swung down on its pedicle. The sigmoid is refashioned to 26-30 Fr on a Nelaton catheter. The tailored sigmoid segment is then transposed to the perineum through an abdomino-perineal window. We usually keep the arch of pubic bone intact and perform inferior pubectomy (from below) and posterior pubectomy (from above). The challenge is in performing the anastomosis between proximal sigmoid end and bulbo-membranous junction. One trick is to keep a guide wire across the anastomosis which helps in insertion of Foley's catheter. Anastomosis is performed with 4-0 Polydioxane suture. The distal anastomosis is done from perineum. We have additionally always mobilised omentum and wrapped around the proximal anastomosis. Clear oral fluids are started on post op day 1 as per the latest protocol. We do not keep patients fasting. Abdominal drain is kept for 5 days and once bowel movements start, drain is removed. Full oral diet is started on day 5-6. Patients are

discharged on day 6-8. Catheter is removed after 6 weeks. We perform pericatheter urethrogram before removal of catheter.

The earliest report of use of bowel segment in urethral reconstruction comes from Hennebert and Jain in 1969 [4]. They described an experimental study in dogs and four short case reports of ileourethroplasty. The other case is from Lee et al. who described the use of a reconfigured flap of sigmoid colon in a patient with complicated pelvic fracture urethral injury along with a simultaneous sigmoid colectomy who did well at 15 months follow up [5].

The largest series of 11 patients is described by Mundy and Andrich where they use various segments of bowel to replace complex long segment strictures of the urethra [6]. The follow up ranged from 2-12 years and 6 patients had an uneventful recovery. Three patients developed proximal anastomotic strictures; one was treated with regular interval dilatation, one requiring revision of the anastomosis and the third requiring a completely new flap. Two patients developed stones – one requiring stone removal and the other requiring a Mitrofanoff procedure as the stone removal resulted in irreversible damage to the ileal mucosa.

We have performed urethroplasty in 115 patients of bulbar urethral necrosis. Amongst these, we performed enitrourethroplasty using sigmoid colon in 3 patients with 100% success [7].

Young fit patients with a competent bladder neck who haven't had previous bowel surgery or any inflammatory bowel disease would be best suited for urethral reconstruction using a bowel segment. We have found as described by Mundy et al., that sigmoid colon offers the best option of the bowel segments. Other bowel segments used are stomach, ascending colon, transverse colon and descending colon. Sigmoid colon is used as this flap can almost always be deployed to the perineum. The vascular arcade of the sigmoid mesocolon arises from the pelvis, making it preferable over other bowel segments. More distal the segment of bowel chosen, longer will be the length of pedicle needed for substitution (Fig. 30.2).

Complications which can result are anastomotic recurrence, formation of stones, long term risk of adenocarcinoma from bowel replacement, failure

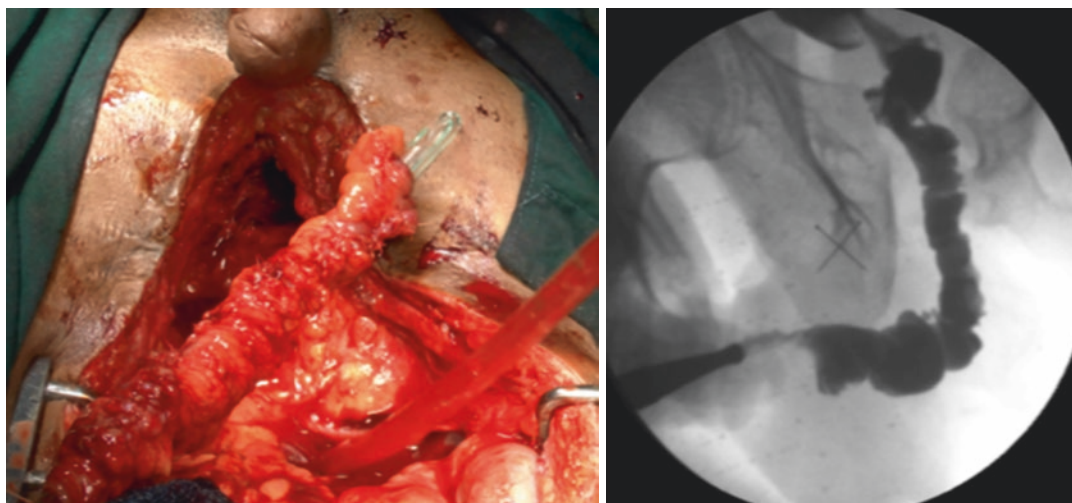


Fig. 30.2 Enterourethroplasty using sigmoid colon

of the procedure and gut complications from the site of harvest. We have seen intestinal anastomotic leak from sigmoid colon in 1 patient which formed a colo cutaneous fistula. It was self limiting and the fistula healed completely in 2 weeks.

30.3 Conclusion

Bowel segment, particularly sigmoid colon, has been used for urethral substitution in patients with complex long segment otherwise unsalvageable posterior urethral strictures with good medium- and long-term success. Patient selection and surgical technique is the key for this success. Use of enterourethroplasty can achieve long term success with voiding per the neo urethra. This is a complex procedure but easily reproducible in properly indicated patients.

Key Summary Points

- For an otherwise unsalvageable bulbo-membranous urethral stricture or post-traumatic defect, a tailored flap of intestine, preferably sigmoid colon, may provide satisfactory outcomes as a urethral substitute if the bladder neck is competent. Placement of the neourethra

can be accomplished in two ways: through its normal anatomical location or a more direct supracrural route.

- Entero-urethroplasty is suitable for patients with pelvic fracture urethral injury with previous failed attempts of urethroplasty and a competent bladder neck. It is unsuitable for those patients with an incompetent bladder neck or a scarred vesico-prostatic urethral junction.
- Most candidates for an entero-urethroplasty will therefore be relatively young, fit and healthy individuals who have suffered a pelvic fracture urethral injury and have failed previous conventional.
- For strictures or traumatic defects of the bulbo-membranous urethra, salvage is technically more difficult and when repeated surgery fails, to find a solution becomes more challenging.

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Perineal Urethrostomy: A Pearl in Failed Urethral Reconstruction

31

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31.1 Introduction

Urethroplasty surgery for urethral strictures is the preferred option to restore durable urethral patency offering excellent success rates. However, failure rates can be as high as 50% [1] for the most challenging patient presentations. In particular, patients with panurethral strictures (most commonly related to lichen sclerosus) and patients with multiple previous failed urethroplasties, such as hypospadias cripples, are considerably difficult to manage. Tissue scarring and a decrease in vascularity -be it due to the sclerosing disease process or secondary to recur-

rent instrumentation- impede wound healing and reepithelialization making stricture recurrences and in case of hypospadias cripples also fistula formation common. In addition to urethral complications, these patients are found to experience a diminished quality of life related to voiding and sexual dysfunction as well as depression [2, 3].

Often viewed as a last resort prior to abandoning the urethral outlet, creation of a perineal urethrostomy (PU) is a highly successful option for men with complex urethral stricture disease, and in some conditions may even halt the progression of disease [4]. However, amongst urologists, there appears hesitation to perform this procedure. In surveys of practicing members of the American and Dutch Urological Associations completed in 2002 and 2008, respectively, less than 10% of urologists had performed a PU in the previous year [5, 6]. Yet in recent years as the field of reconstructive urology continues to advance it appears that perineal urethrostomies are increasingly considered. Fuchs et al. noted a nearly ten-fold increase in PU procedures from 2008 to 2017, with also a trend towards performing the procedure in younger patients likely reflecting improved awareness of the limitations of tissue transfer [7].

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31.2 General Indications

In general, PU is a reversible procedure, and this is utilized during staged urethroplasty. A generation of a neomeatus in the perineum is

essential during the first-stage. In this setting, despite the intention for a complete reconstruction six or more months later, many patients may ultimately find PU as an acceptable diversion and elect to forgo the second stage. In fact, in those undergoing staged urethroplasty, only 24–58% of men pursued second stage, leaving 42–76% with a functional perineal urethrostomy [4, 8, 9].

More commonly, however, definitive PU is performed and the general indication is in individuals with complex anterior urethral strictures. Compared to extensive urethral reconstruction, PU is a relatively minor surgical procedure associated with earlier return to normal activity and catheter removal, while avoiding the morbidity of graft harvest site morbidity and maintaining more typical anatomy for aesthetic reasons. As such, PU may be a more sensible procedure in the elderly or in those with severe medical comorbidities for whom a prolonged surgery may be associated with higher perioperative morbidity and mortality [4]. Other times, the surgeon may recommend a PU due to poor quality of urethral and penile tissue, exhaustion of graft materials, and understanding of the disease process, which can contribute to inadequate reconstruction [4, 9]. Aptly put by Peterson et al., “heroic measures may not be justified” [4]. Finally, patients who would otherwise be candidates for a single-stage repair may elect to undergo PU instead of complex urethroplasty due to a history of multiple prior failed procedures and treatment fatigue. Barbagli et al. reported that patients electing PU instead of a complex urethroplasty were a mean age of 53 years, had undergone on average 4.5 procedures for hypospadias repair or 4.1 failed urethroplasty for other urethral conditions, and were unwilling to accept the possibility of another failed urethroplasty [9].

Outside of urethral stricture disease, a PU may be indicated in patients with traumatic or penile amputation. Following penile trauma or in the setting of penile or urethral malignancy, PU may be utilized as an alternative to placement of a suprapubic catheter or avoid more extensive surgery to create a urinary outlet

such as appendicovesicostomy or even supravescical diversion such as an ileal conduit. The PU permits continent voiding and avoids complications associated with prolonged catheter use including urinary tract infection, bladder calculi, catheter blockage, and increased risk of squamous cell bladder carcinoma or risks of extensive surgery.

It should be noted that not all patients with urethral pathology should be considered for creation of PU. In patients with coexistent proximal urethral disease (posterior urethral stenosis or bladder neck contracture), a PU would obviously not relieve obstructive symptoms. In patients with urinary incontinence, creation of a PU could worsen urine leakage by bypassing the stricture, which in many cases comprises the patient’s continence mechanism. In this setting, continuous leakage of urine through a PU is likely to cause wound complications. Additionally, the presence of a PU would make subsequent placement of an artificial urinary sphincter more challenging technically as well as likely increase the risk of complications [10].

31.3 Perineal Urethrostomy Techniques

There are several techniques described to generate a PU and approaches can broadly be divided into two categories: those associated with transection of the urethra and non-transecting techniques.

Non-transecting techniques such as the Johanson and Blandy techniques preserve the urethral plate, and thereby retrograde blood supply from the dorsal penile artery. This may decrease the rate of postoperative complications, specifically stenosis of the neomeatus [11]. Additionally, by maintaining the urethral plate, these techniques allow for the possibility for the urethra to be re-tubularized at a later date. In contrast, advantages of transecting techniques, such as the 7-flap, lotus petal flap, and also augmented PU techniques, are a more complete mobilization of the proximal urethral stump. This facilitates a tension-free anastomosis, especially in patients with increased

skin-to-urethra length (e.g., obese patients or patients with very proximal urethral strictures). However, while generally also reversible, the urethral transection and ligation of the distal urethra makes a subsequent reversal a more complex endeavor.

31.3.1 Non-transecting Techniques

31.3.1.1 Johanson Technique

Originally described in 1953 as the first-stage of a staged urethroplasty for pendulous urethral strictures, the Johanson technique has been adapted for use in the bulbar urethra for staged procedures as well as for permanent diversion in the form of PU [12]. In principle, the Johanson technique for PU creation involves marsupialization of the urethra to adjacent perineal skin and serves as blue-print of generating a PU as its evolution by the more elaborate techniques discussed below have some elements in common with the Johanson technique.

The patient is placed in a high lithotomy position. A vertical midline incision is made on the perineum extending from the posterior aspect of the scrotum to approximately 1–2 cm anterior to the anus (Fig. 31.1). After exposing the bulbar urethra, a ventral longitudinal urethrotomy is performed and extended proximally until healthy urethra is encountered. An incision of several centimeters is recommended to avoid stenosis of the neomeatus (Fig. 31.2). The presence of proximal urethral strictures, stenoses or bladder neck contractures should be excluded either with calibration to 24–28F or cystoscopically. As significant bleeding of the incised corpus spongiosum can be encountered, the cut edge of the corpus spongiosum can be oversewn with running locked absorbable sutures. The edges of the urethrotomy are then matured to the perineal incision skin edges with interrupted absorbable sutures [1, 8, 13].

In the event that the urethrostomy cannot be matured to the perineal skin in a tension-free fashion, scrotal skin can be invaginated towards the urethrotomy, with a vertical incision made along the median raphe of the scrotum to be used

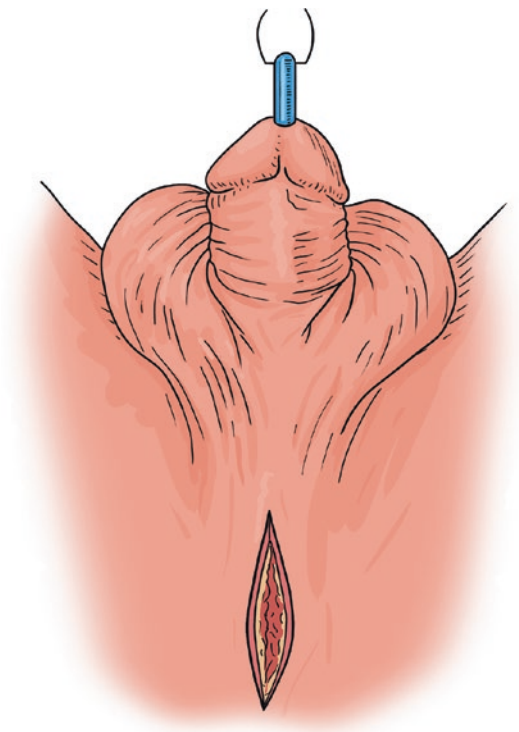


Fig. 31.1 Johansen PU: Midline incision over the urethra

for stoma maturation [1, 8]. A urethral catheter is placed through the neomeatus but can typically be removed within 1 week.

The Johanson technique is a familiar concept to most reconstructive urologists due to its use as a first-stage approach for staged urethroplasty. However, due to the limited elasticity of the perineal skin, there may be significant tension when maturing the urethrostomy, particularly at the posterior-most aspect. This may predispose the incision to wound dehiscence and subsequent stenosis of the neomeatus. To address this concern, an invaginated scrotal flap as described above should be considered albeit this can be inconvenient for voiding. Alternatively, McKibben describe the utilization of a Z-plasty technique on the inferior aspect of the perineal incision to construct a tension-free urethrostomy with excellent success [14]. Regardless, use of this approach may be best reserved for thin individuals with pliant perineal skin in whom a tension-less anastomosis is more feasible.

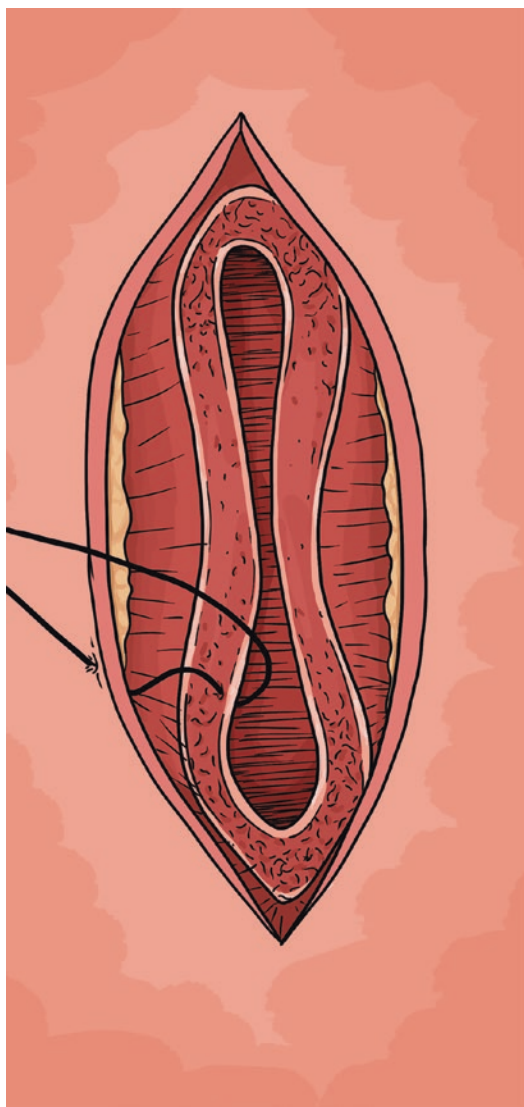


Fig. 31.2 Johansen PU: The urethra is opened longitudinally for several centimeters and the skin anastomosed to corpus spongiosum and mucosa

31.3.1.2 Blandy Technique [15, 16]

Developed as a modification of the Johanson technique due to high stenosis rate at the proximal apex of the PU, this technique was first described in 1968 [15]. By developing an inverted U-shaped scrotal flap, this approach can be used as a first-stage of a staged urethroplasty or for definitive PU.

The patient is placed in high lithotomy position and urethroscopy may be performed at the start to identify the proximal end of the stricture. This is marked on the skin and marks the point at which the flap would need to reach. The apex of the flap is marked out to be 3 cm anterior to this to allow the flap to drop into the urethra without tension (Fig. 31.3). The flap is marked out with the distal end of the flap being about 3 cm in width and a corresponding base created with an approximately 3:1 ratio. A 4 cm vertical midline incision is marked out anterior to the apex of the flap to form the edges of the dorsal urethral plate. Incision is made in the pre-marked lines and the flap is developed with a full thickness fat pad directly off of the underlying bulbocavernosus muscle in order to ensure good vascular supply to the apex of the flap. Next, the bulbar urethra is exposed, a ventral longitudinal urethrotomy is performed and extended proximally while placing stay sutures through mucosa and corpus spongiosum (Fig. 31.4) until healthy urethra is encountered and proximal urethral obstruction excluded. The urethrotomy should measure several centimeters (about 4–6 cm) to ensure durability of an adequately sized opening. The edge of the corpus spongiosum and the edge of the urethral mucosa are closed laterally with 4–0 absorbable sutures (Fig. 31.5). To mature the urethrostomy, three apical sutures are pre-placed in the proximal urethral opening and corresponding area on the flap (Fig. 31.6) allowing for optimal visual exposure, which is obscured once the inverted U-shaped flap is advanced into the defect. Next, the sutures are tied leading to a parachuting of the perineal skin flap to the proximal urethral stump (Fig. 31.7). The remaining skin incisions which were not utilized in maturing the PU are then re-approximated with absorbable suture (Fig. 31.8). A 20 Fr urethral catheter is placed and removed after 7–10 days.

The main drawback of the Blandy technique is that it relies on an accurate pre-incision assessment of the length of the flap needed to construct a tension-free anastomosis. Unfortunately, the pre-operative assessment of urethral stricture disease

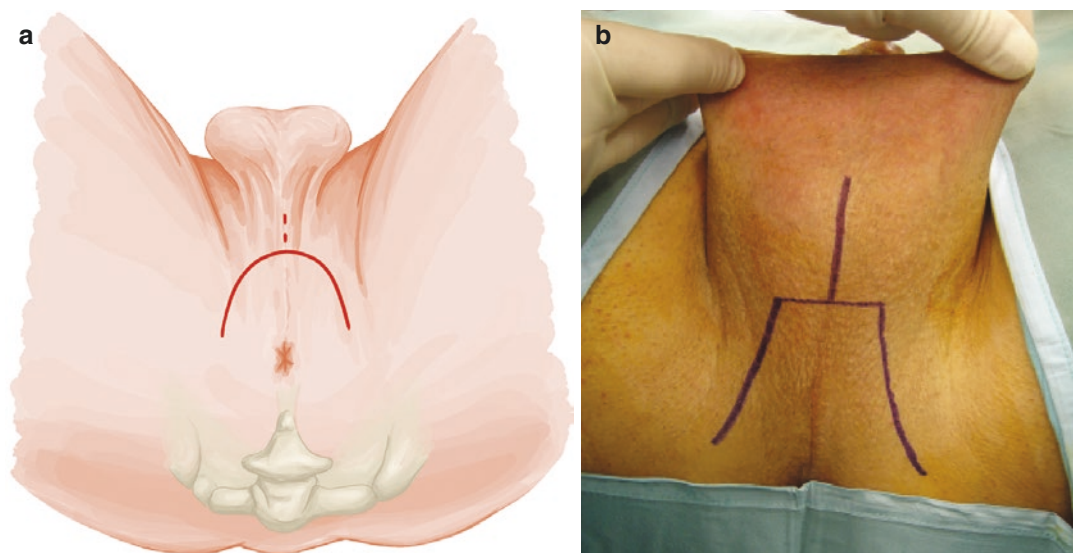


Fig. 31.3 Blandy PU: Outline of the skin incision either as inverted U (Panel **a**) or as trapezoid (Panel **b**). Note the perpendicular incision in the midline of the scrotum

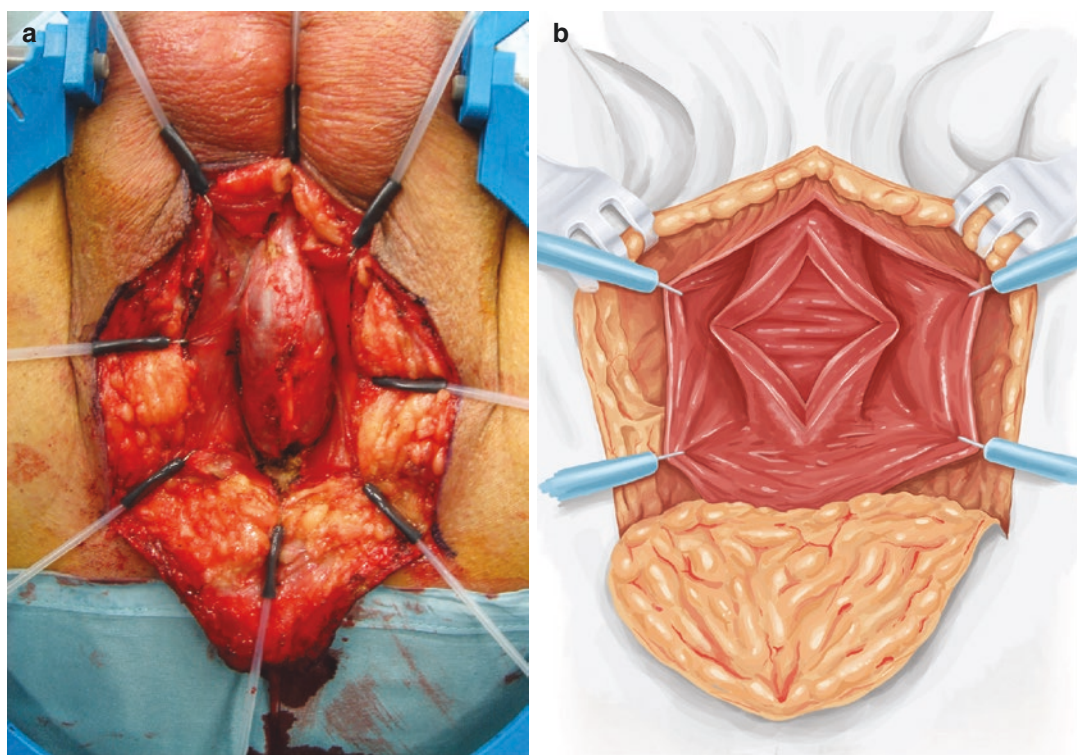


Fig. 31.4 Blandy PU: The urethra is exposed (Panel **a**) and then opened (Panel **b**). A ring retractor with hooks helps to expose the field

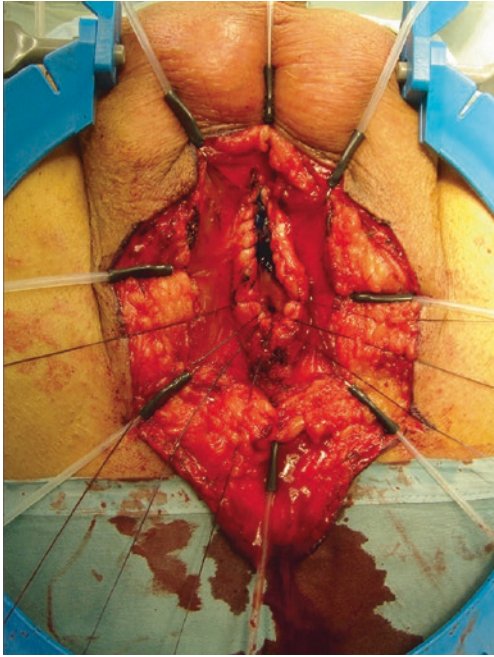


Fig. 31.5 Blandy PU: A running stitch through mucosa and corpus spongiosum closes the corpus and controls bleeding

is imperfect, with one study noting a correlation coefficient of only 0.69 between preoperative RUG and intraoperative stricture measurement [17]. It follows that if the stricture extends more proximally than expected before the initial incision, the flap may not be long enough to ensure a tension-free anastomosis and predispose to PU failure. Also, in its original report, about 10% of patients required a revision due to necrotic tip of the flap and some patients needed to self-dilate to break down skin bridges between suture lines. [16]

31.3.2 Transecting Techniques

31.3.2.1 7-Flap Technique

The 7-flap technique was first described in 2011 by French et al. [18] This approach utilizes a lateral-based perineal skin flap to create the urethroostomy. It also employs a vertical midline perineal incision, affording flexibility if a one-stage urethral reconstruction is intended but not possible and instead a PU is necessary. Conversely,

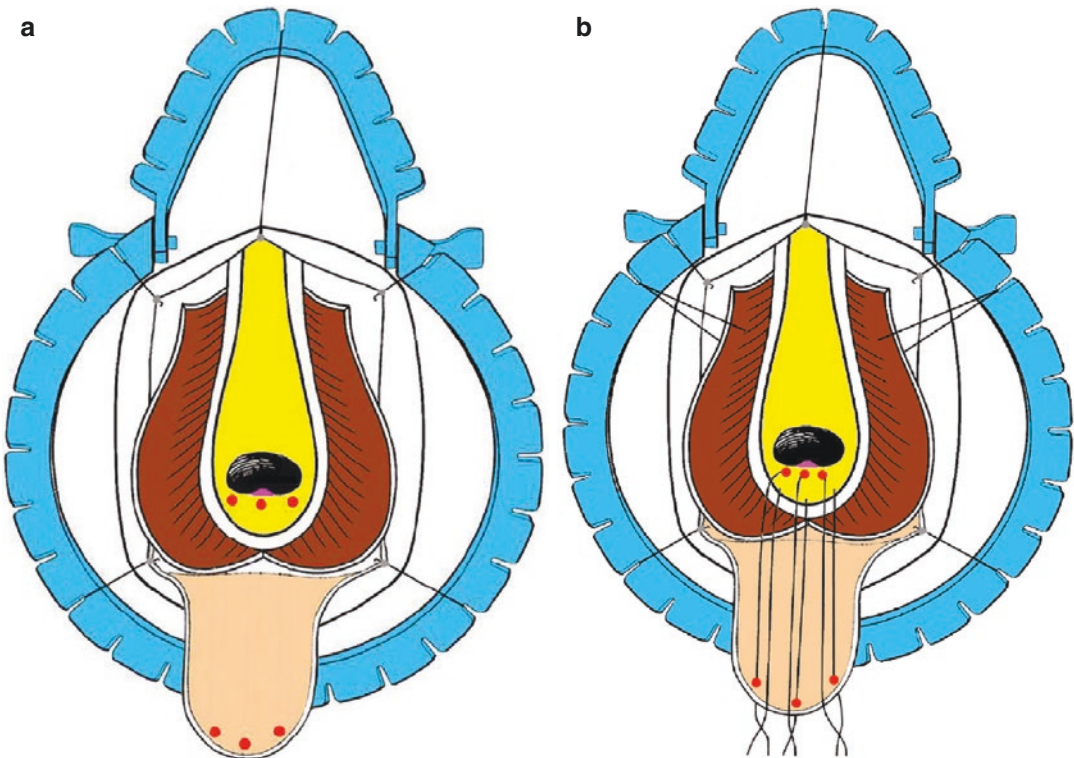


Fig. 31.6 Blandy PU: Three apical sutures are marked and passed in front of the verumontanum and placed in corresponding sites on the apex of the inverted U-shaped perineal skin flap (Panel **a** and **b**)

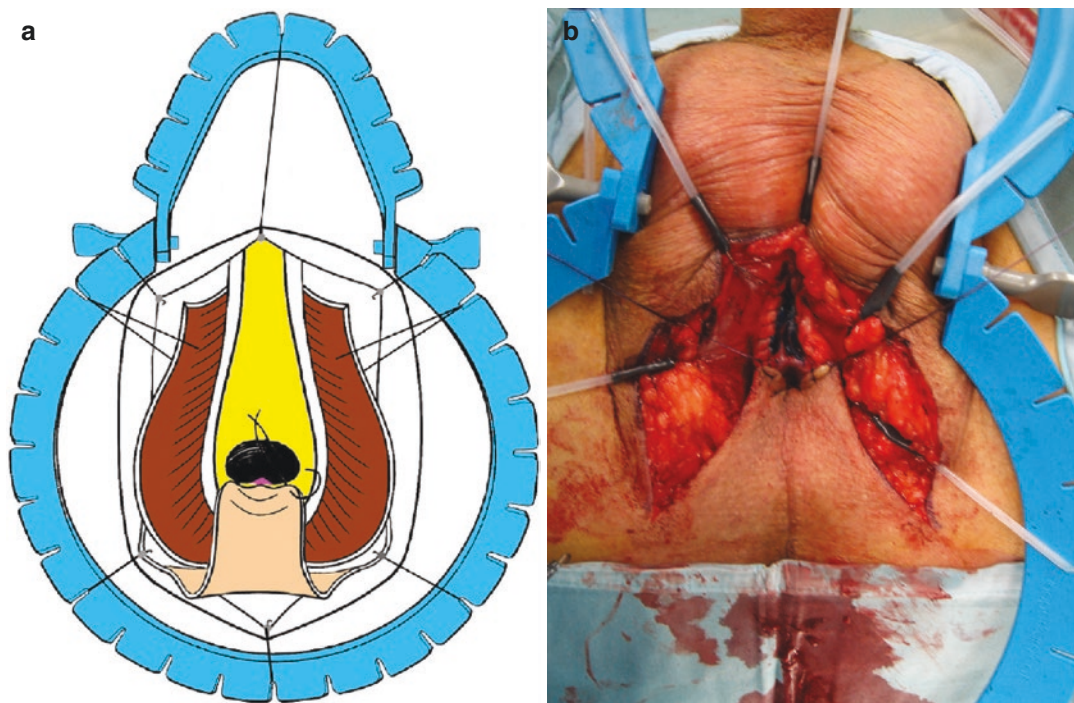


Fig. 31.7 Blandy PU: Upon tying the 3 sutures, the perineal skin flap is parachuted into the proximal urethral mucosa (Panel a and b)

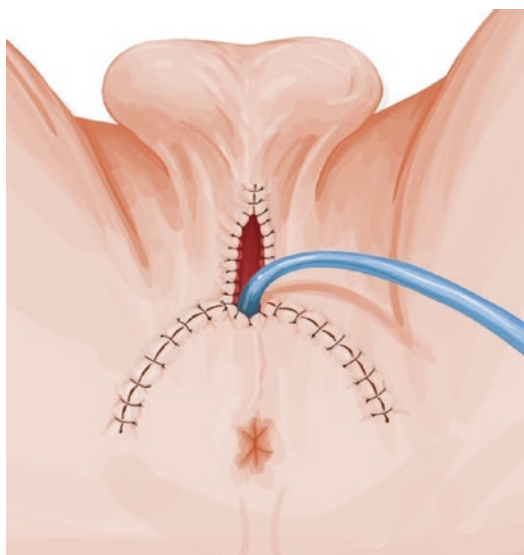


Fig. 31.8 Blandy PU: Remaining perineal skin is sutured to the urethral plate and remaining skin defect closed. A 20 Fr urethral catheter is placed and removed after 10 days

if a PU is being pursued but an orthotopic reconstruction is instead deemed possible this can be performed through this incision.

The patient is positioned in lithotomy position and the 7-flap delineated (Fig. 31.9) and the skin incised through a vertical midline perineal incision which is the stem of the “7”. The bulbar urethra is exposed and transected at the distal-most possible level as determined by cystoscopy. The distal urethral stump is oversewn with running absorbable suture. The proximal urethral segment is spatulated at the 9 o’clock aspect for about 1 cm and proximal urethral patency ensured by calibration or cystoscopically. On the same side as the urethral spatulation, the 7-shaped skin flap is created and tailored to fit the distance to the proximal apex of the spatulation (Fig. 31.10). The incision can be extended if a longer flap is needed to achieve a tension-free anastomosis. When developing the flap, it is necessary to ensure adequate thickness of the flap to prevent flap necrosis as well as an appropriate ratio of base to length of the flap (3:1 or more).

The apex of the 7-shaped flap is then matured to the apex of the spatulation in a “yin-yang” configuration using absorbable suture. The contralateral side of the proximal urethra is matured

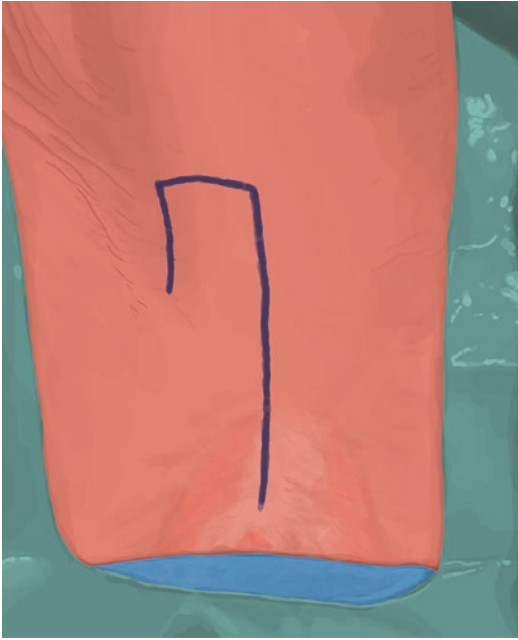


Fig. 31.9 7-Flap PU: Skin marking showing a squared 7-shape figure with the long vertical base placed in the midline

to adjacent perineal skin and the remaining incisions are re-approximated using absorbable suture. If the distance from the perineal skin to the proximal urethral stump remains too long, a second 7-flap can be fashioned on the contralateral aspect of the flap incision. The skin is closed to restore the perineum (Fig. 31.11). A catheter is placed through the neomeatus and maintained for several days [18–20].

The main advantage of the 7-flap technique is that the flap is fashioned *after* bulbar urethral dissection thus enabling an appropriately tailored skin flap to the patient's urethral stump in order to achieve a tension-free anastomosis. This allows for greater flexibility in those with proximal urethral stricture disease as well as in obese individuals, who have an increased skin-to-urethra distance. However, this flap is considered a random pattern flap and therefore the length should not extend beyond three times the width of the base in order to preserve vascularity to the flap. Notably, while the 7-flap technique

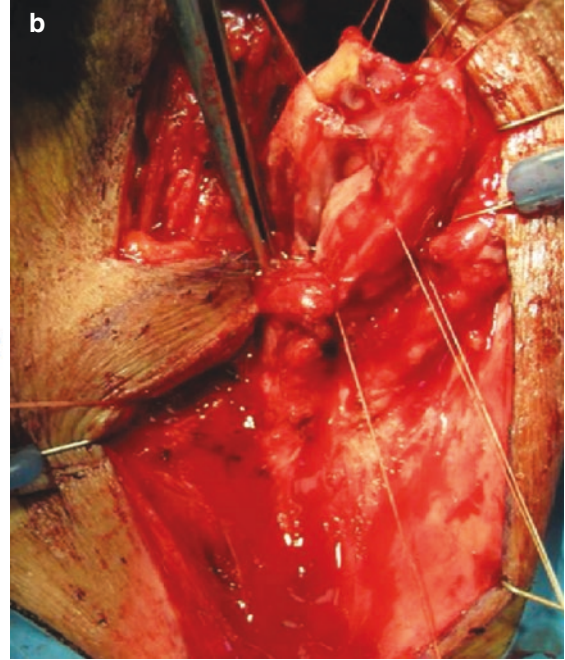
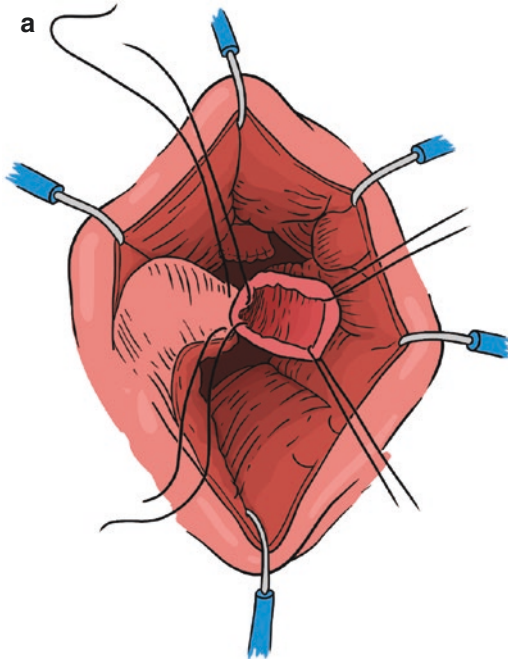


Fig. 31.10 7-Flap PU: Right lateral perineal skin flap is rotated medially, proximally and advanced down towards the proximal end of the urethrotomy (Panel a and b)

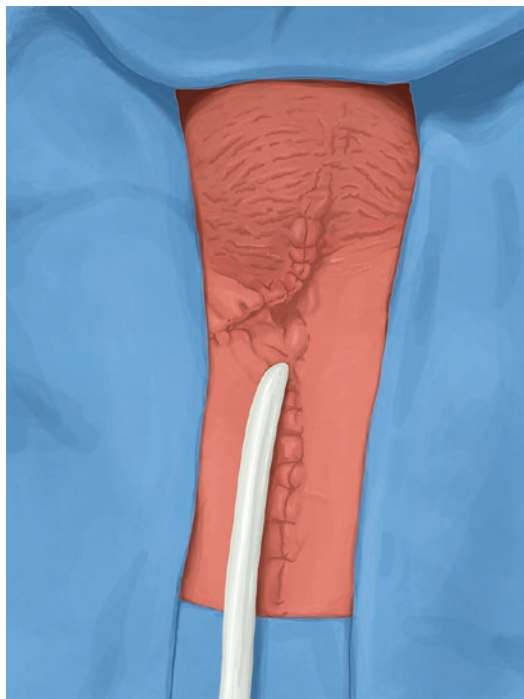


Fig. 31.11 7-Flap PU: Final result of the 7-flap perineal urethrostomy after skin closure and catheter placement

as originally described involves transection of the urethral plate, it has been adapted into to a non-transecting technique for patients with more distal strictures with good success rates [14].

31.3.2.2 Lotus Petal Flap

The lotus-petal flap was originally described in 1996 for use in the reconstruction females with perineal conditions by Yii et al. [21]. Its indications have since expanded to wounds of the male perineum and were described in 2018 for adaptation to PU bei Reilly et al. [22]. The strength of this technique is the use of a vascularized tissue based on regional perforator anatomy. This allows the skin to be mobilized deep into the perineum and shaped into a tubular structure whilst maintaining adequate blood facilitating a tension-free closure in high risk individuals.

The patient is placed in the lithotomy position. Using a Doppler ultrasound, perforators of the internal pudendal artery are identified and marked on perineal skin (Fig. 31.12). A midline vertical perineal incision is made and the bulbar urethra

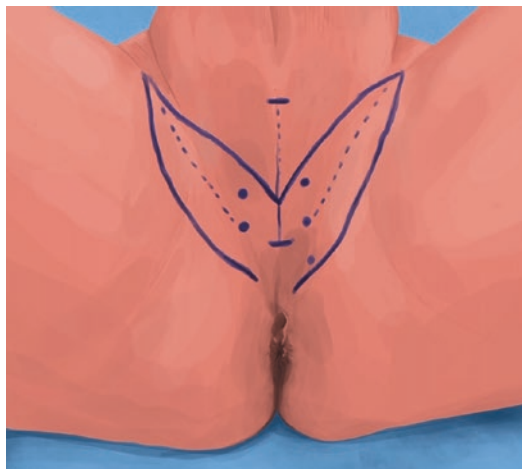


Fig. 31.12 Lotus Flap PU: Skin markings following perforator identification using hand-held Doppler ultrasound

is exposed. The urethra is transected as distally as possible (right at the point where healthy mucosa can be identified cystoscopically) The distal urethra is oversewn using absorbable suture and the proximal urethra spatulated and calibrated to ensure proximal urethral patency [22].

The distance from the proximal urethral stump to skin is measured and an appropriate length of lotus flap is marked out incorporating the previously identified perforating vessels. Incision is made along the marked flap and perforating vessels dissected out and preserved (Fig. 31.13). The flap is folded on itself to form a tube and secured with 4–0 monocryl. To achieve this, the skin flap can be completely islanded if desired (Fig. 31.14) or left with a posterior skin bridge intact. 4–0 monocryl absorbable sutures are then used to inset the skin flap to the urethral margin incorporating the spongiosum as well. The donor site is closed in layers over a suction drain, which is usually removed on the first post-operative day. A final 16 Fr urethral catheter is placed and removed in 2 weeks (Fig. 31.15) [22].

The advantage of the lotus petal flap technique is the utilization of a flap of tissue uninvolved by the original disease process, and with preservation of a perforating vessel, it maintains a rich vascular pedicle permitting the use of a larger swathe of tissue compared to the 7-flap technique. This approach is also flexible with regards to modifying

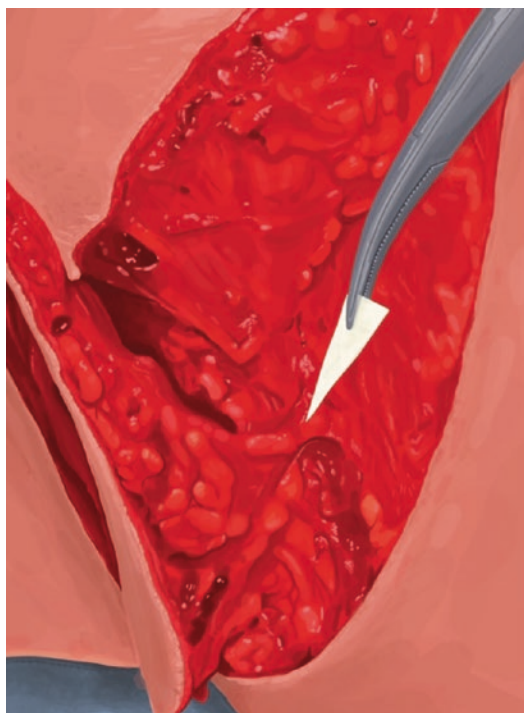


Fig. 31.13 Lotus Flap PU: Elevation of flap and identification of perforator vessel

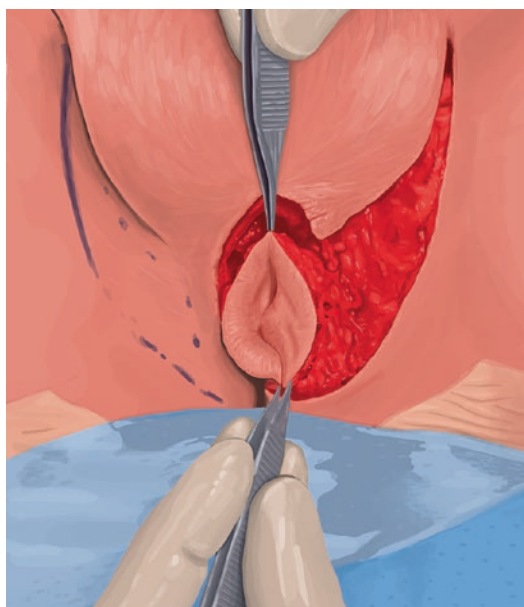


Fig. 31.14 Lotus Flap PU: Petal flap completely islanded and tubularised

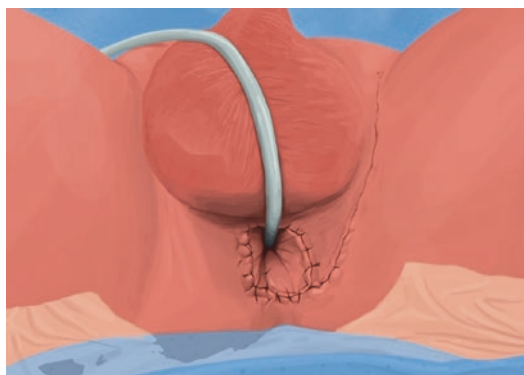


Fig. 31.15 Lotus Flap PU: Final result of the lotus petal flap perineal urethroplasty at the end of operation

the orientation of the flap to suit the defect appropriately. The lotus petal flap is especially advantageous in individuals with very proximal urethral stricture disease or those who are very obese, as it serves to bridge the gap between the urethral defect and perineal skin with a vascularized tube. Drawbacks include the challenge of perforator flap dissection which may require assistance by a plastic surgeon as well as the potential for impaired blood supply due to original disease process specifically trauma and radiation.

31.3.2.3 Augmented Perineal Urethroplasty Using a Dorsal Buccal Mucosal Graft (DeLong) [23]

This technique was recently described by DeLong et al. in 2017. Incorporating buccal mucosal graft in the creation of perineal urethroplasty allows to address urethral strictures that extend far into the proximal bulbar or membranous urethra as well as to address patients at high risk of recurrence (e.g. lichen sclerosus or previous radiation). This technique brings the urethroplasty to the skin surface rather than burying a skin flap deep into the perineum as in the other transecting techniques. At the same time the augmentation with buccal graft also reduces the risk of circumferential scarring of the neomeatus as unlike skin it will not contract secondary to the chronic inflammation caused by urine exposure [24].

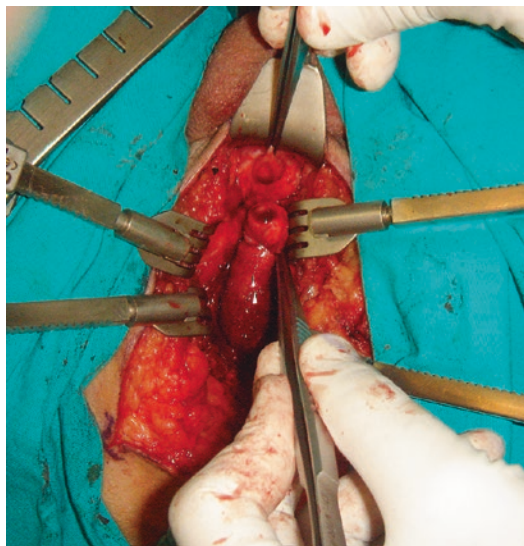


Fig. 31.16 Augmented PU: The corpus spongiosum is dissected and then transected

The patient is placed in a lithotomy position and an inverted U incision made in the perineum. The bulbospongiosus muscle is divided in the midline followed by mobilization and transection of the corpus spongiosus (Fig. 31.16). The urethra is incised at its dorsal aspect and the incision carried out proximally until healthy mucosa is seen and the lumen can be calibrated to 30F (Fig. 31.17). The distal urethral stump is closed and a fragment of buccal mucosa graft is harvested to fit the dorsal urethral defect. The graft is placed dorsally and anastomosed to the edges of the urethra closing its dorsal aspect. Prior to complete closure, the graft is quilted to the corpora cavernosa (Fig. 31.18) to ensure vasculatization and survival. Cutaneous margins are closed with 4–0 Vicryl sutures, and the remaining wound is closed in layers. A final 14 Fr silicone catheter is placed and removed after 10 days (Figs. 31.19 and 31.20).

31.4 Surgical Outcomes

Reported success rates for creation of a PU range from 70% to 100%. In two series, the success rate of the Johanson technique for

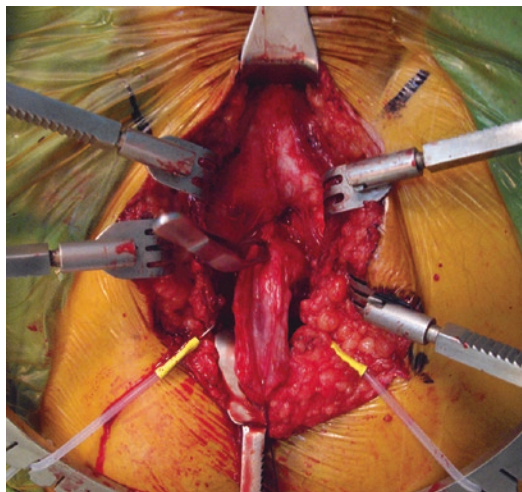


Fig. 31.17 Augmented PU: A dorsal urethrotomy is carried out proximally until healthy mucosa is encountered

creation of a PU in urethral stricture disease approached 75% with a mean follow up of 2–4 years [1, 8]. Success using the Blandy procedure is reported at 70–88% with average follow up of at least 1 year [1, 25], and stratified by the stricture etiology: While patients with prior failed hypospadias repair had better success rates, those with a history of trauma or infection had worse outcomes [1, 9]. Compared to the Johanson technique, improved outcomes with the Blandy technique were reported (74% vs 88%, respectively), although this was not statistically significant. Anecdotally, the Blandy approach is technically easier with regards to maturing the posterior aspect of the urethrostomy [1].

The 7-flap technique was reported as successful in 93–95% of all patients with urethral stricture disease with a mean follow up of 32–56 months [14, 19, 20]. While the lotus petal flap has only recently been applied to use in the creation or revision of PU, this approach was successful in all three patients when utilized for revision (2 patients) or primary (1 patient) PU with follow up of at least 22 months [22]. In summary, PUs can generally be considered to be highly successful with decreased success rates in those

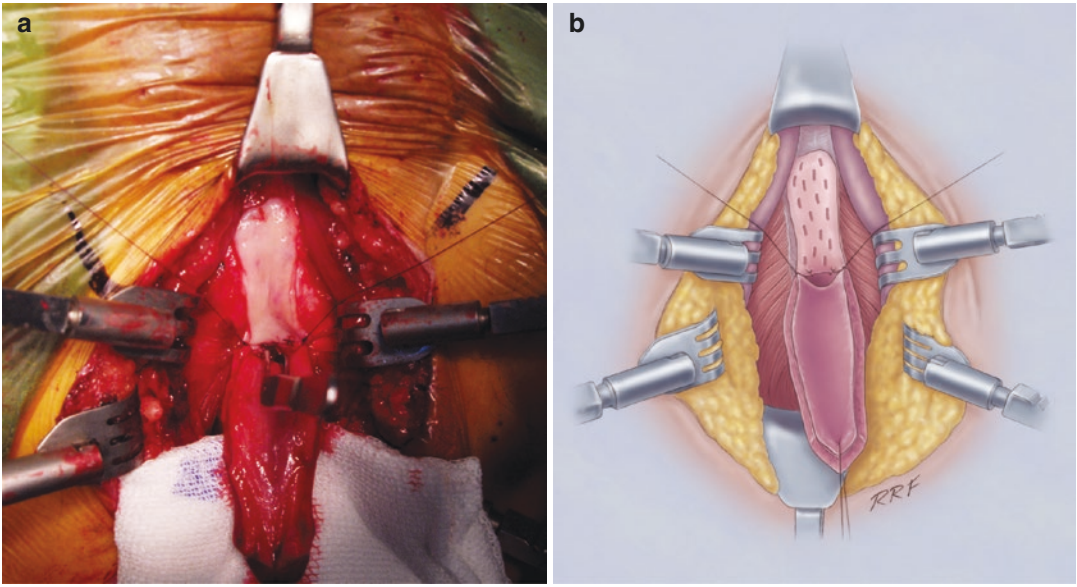


Fig. 31.18 Augmented PU: A buccal mucosa graft is sutured to the urethral margin dorsally and quilted in the graft bed



Fig. 31.19 Augmented PU: Final result at the end of operation



Fig. 31.20 Augmented PU: Final result at 1 month after the operation

patients that comprise a challenge for any kind of reconstruction. DeLong et al. reported an 80% success rate for the augmented perineal urethrostomy with a mean follow-up of 45 months (range 6–136 months) but all patients had complex ure-

thral strictures involving the proximal bulbar or membranous urethra. An additional 9% of patients successfully underwent revision with oral mucosa graft and remains recurrence free [23].

31.5 Special Populations

When creating a PU, special considerations should be made in specific populations in order to improve surgical outcomes.

31.5.1 Lichen Sclerosus

Lichen sclerosus represents a highly heterogeneous population with variable involvement of the urethra and perineal tissue. Amongst patients with lichen sclerosus, PU success rates range from 72% to 100% [4, 25, 26]. Lopez et al. noted that based on multivariate analysis, individuals with a history of lichen sclerosus were over three-times more likely to require re-intervention following PU creation than those with stricture disease due to failed hypospadias repair or idiopathic etiology [27]. One potential reason for poor success rates in this population is related to possible disease recurrence at the neomeatus. In order to mitigate this, DeLong et al. utilized a dorsal onlay buccal mucosal graft to bring the urethrostomy to the surface of the perineum decreasing anastomotic tension and to prevent circumferential scarring of the urethrostomy. Amongst patients with lichen sclerosus, the authors reported an 80% success rate with a mean follow-up of 45 months [23]. It should be noted that the 2% malignancy risk reported to be associated with lichen sclerosus is not negated by generation of a PU, and malignant transformation of biopsy-proven lichen sclerosus at the PU site has been reported [28].

31.5.2 Obese Patients

In patients with a long skin-to-urethra distance, it can be challenging to achieve a tension-free anastomosis when maturing the urethrostomy. Transecting techniques allow a better mobilization of the proximal urethral stump and, using a local flap such as the 7-flap or lotus petal flap, also allow for custom tailoring of the flap to facil-

itate a tension-free anastomosis. In two studies, use of a 7-flap in obese patients was 93–96% successful thus similar to the success rates in non-obese patients [14, 19, 20].

31.5.3 Prior Pelvic Radiotherapy

Patients with prior pelvic radiotherapy were reported by Myers et al. to have a 12-fold increased risk of PU stenosis on multivariate analysis attributed to a known predisposition for developing scar tissue formation and poorer wound healing. Despite this risk, the authors still recommend PU creation in this setting due to the absence of a viable alternative and overall success with secondary treatments such as urethral dilations or PU revision. The authors do emphasize that these patients should be managed using a non-transecting technique in order to preserve retrograde blood supply to from the dorsal penile artery [11].

31.5.4 Fournier's Gangrene

Patients with a history of Fournier's gangrene are another challenging population for the reconstructive urologist. The condition leads to obliterated tissue planes and irregular vascularity of the perineum, and as such, local tissue flaps are unreliable and should be avoided. Regardless of approach used, success is poor, and even with the use of a dorsal onlay buccal mucosa graft in one cohort two of three patients failed [23]. However, PU may be the only other option short of suprapubic tube or uraprivesical diversion and should be considered.

31.6 Surgical Pearls, Complications and Pitfalls

To improve the chance for success several points should be considered either pre- or intra-operatively.

The presence of some healthy proximal bulbar urethral tissue should be identified during preoperative work-up because if the stricture extends too proximally the risk of failure is increased due to tension at the matured urethrostomy. Although this holds true for all techniques, knowledge of a variety of techniques including those designed to bring the skin to the urethral stump (e.g. 7-flap, Lotus-flap) or to lengthen the stump (augmented PU) to decrease the tissue tension is therefore recommended.

Whenever a flap is created (Blandy, 7-flap, Lotus flap) it is important to allow enough length to avoid tissue tension at point of anastomosis as well as to use a broad-enough base (minimum 3:1) to avoid necrosis of the apex of the flap.

Using a wire placed through the strictured area allows for a more precise urethrotomy and helps to preserve quality of the tissue possibly needed for reconstruction while also decreasing tissue trauma that will negatively influence wound healing. If the urethra is obliterated, passage of a flexible cystoscope or an 18F van Buren sound through the suprapubic tract and into the proximal urethra can help in identifying the lumen and minimize trauma (“cut to the light”).

The urethrotomy should be extended proximally to allow passage of 30F sound ensuring adequate caliber of healthy proximal urethra even if the stump becomes short, and finally, the use of interrupted anastomotic sutures allow to decrease the tension of the anastomosis between flap and urethra.

However, as previously noted, PU failure can occur in up to 30% of cases requiring re-intervention. Risk factors for failure include a persistent or recurrent disease process (such as lichen sclerosus or urethral cancer), wound infection, undue tension at the anastomosis, or inadequate caliber of the proximal urethral stump. Additionally, patients with a history of radiotherapy, traumatic or infective etiology to stricture, or prior failed urethroplasty should be considered at higher risk for failure [22].

The most common complication encountered is stenosis of the neomeatus, and this can be a difficult condition to manage. If stenosis is mild, the patient may be taught to perform intermittent self-

dilation of the neomeatus. In more severe cases of stenosis, the PU may be recreated or revised using a variety of techniques. If available, local skin flaps can be incorporated in the PU (Blandy, 7-flap, Lotus petal flap [9, 11, 29]) or as a Y-V advancement flap [30]. However, if the patient is deficient of healthy local skin (such as in the setting of perineal recurrence of lichen sclerosus, Fournier’s gangrene, or extensive perineal trauma) alternative tissue may be utilized as grafts. Kamat et al. describe a composite stoma formed by incising the PU stomal opening at 4-o’clock, 7-o’clock, and 12-o’clock, forming a “cloverleaf” appearance, with placement of three triangularly shaped buccal mucosal grafts into these raw areas. In this series, three of four patients had successful repair at up to 36 months follow up while one remaining patient required monthly self-dilation but no surgical revision [24].

In the setting of multiple prior urethroplasty procedures, ample buccal mucosa may be unavailable for use in stomal revision. To address this, Lumen et al. described the use of a meshed split-thickness skin graft to reconstruct a urethrostomy in a patient with a history of an obliterated PU following treatment for penile cancer which remained patent at 6 months follow up. The main advantage of this graft material is the large availability in those with prior reconstructions; however, as meshed split-thickness skin grafts are prone to retraction it is necessary to broadly spatulate the urethral stump to compensate [31].

Ultimately, if the above techniques fail, the urethral outlet may need to be abandoned altogether with and urinary diversion established. Options are a chronic suprapubic catheter, construction of appendicovesicostomy, or creation of alternative reservoir (e.g. ileal conduit) with or without simple cystectomy.

31.7 Patient Reported Outcomes

In appropriately selected patients, the overall satisfaction following PU is generally excellent. In one large study analyzing patient sat-

isfaction in 173 patients with urethral stricture disease undergoing PU as part of a staged procedure between 1978 and 2007, Barbagli et al. reported that 73% of patients declined to undergo the second stage of urethroplasty; in addition, 97% were satisfied or very satisfied with the results of PU at a median 6 years follow-up and would undergo the procedure again. In this cohort, 84% of patients also noted no psychological, voiding-related, or sexual problems caused by the PU, despite an overall failure rate of 30% requiring one to five further procedures. In addition, 82% of the cohort denied problems with their partner related to PU and notably, patient satisfaction was not influenced by patient age [9].

PU may not be an acceptable option in some patients related to religious, hygienic, cultural or psychological reasons. Specifically, voiding in a sitting position as well as changes in sexual function may be problematic for patients. However, Murphy et al. recently reported that PU does offer improvement in obstructive symptoms without affecting sexual health, and, when adjusting for stricture complexity, offer comparable patient satisfaction to those undergoing anterior urethroplasty [32]. Additionally, Barbagli et al. have noted that many patients with complex urethral stricture already are accustomed to voiding in a seated position due to age and/or voiding difficulty, and so the transition to a PU is not as difficult in practice as it may be conceptually [9].

31.8 Conclusion

Creation of a PU offers a simple, highly successful option in the management of an exceedingly complex condition and should not be viewed as last resort or even defeat. PUs are being increasingly utilized due to an increasing awareness of the limitations of tissue transfer, a better understanding of the disease course, and, perhaps most importantly, excellent patient satisfaction with the outcome.

Key Summary Points

- Creation of a perineal urethrostomy is indicated in the treatment of panurethral strictures and complex anterior urethral strictures. Patients in these populations typically have a long history of urethral instrumentation and reconstruction. Despite being offered complex urethral reconstruction, some patients may prefer perineal urethrostomy due to treatment fatigue. PU creation is also indicated for urinary diversion in penile and urethral malignancies.
- PU is relatively contraindicated as sole procedure in patients with bladder neck contracture or coexistent proximal urethral stenosis, and should be avoided in men with urinary incontinence.
- Non-transecting techniques such as the Johanson and Blandy approaches facilitate retrograde blood flow from the dorsal penile artery and may prevent stenosis of the neomeatus.
- Transecting techniques such as the 7-flap, the lotus petal flap, and augmented perineal urethrostomy can help to achieve a tension-free anastomosis in patients with a longer skin-to-urethra distance such as obese patients.
- Overall success rates for PU creation range from 70–100%, with patients with a history of radiation and lichen sclerosus experiencing increased failure rates. Patients with a history of hypospadias may have better outcomes than those with other stricture etiologies.
- Patient satisfaction is generally high with the perineal urethrostomy.

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Urinary Diversion: The Last Resort of Male Urethral Reconstruction

32

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32.1 Introduction

Despite its technical difficulties, results from large series and systematic reviews have demonstrated that urethroplasty is the best option for the management of urethral strictures, with around 90% long term success rate in experienced hands [1–3]. For the small number of patients that fail revision urethroplasty, decline repeated urethral surgery, or are unfit for further reconstruction, urinary diversion remains a viable solution for appropriately selected patients.

For this subgroup of patients, urinary diversion options include perineal urethrostomy (Chap. 30) or continent or incontinent urinary diversion, which may require concomitant bladder neck closure and/or bladder augmentation, which will be the focus of this chapter. Urinary diversion surgery has significant early and late morbidity and mortality risks. When performed for quality of

life indications such as refractory urethral stricture, it should be considered a last resort and patients should be appropriately counselled.

32.2 Etiology of Failure

Urethroplasty failures have been attributed to inferior tissue health. This may be secondary to extensive fibrosis in the setting of multiple previous endoscopic procedures, radiation therapy, poor vascular supply, prosthesis/ foreign body erosion, infection, and/ or long strictures or multiple previous attempts at urethroplasty. Often the etiology is multi-factorial with patients presenting with more than one risk factor increasing the risk of failure.

For patients that have failed repeated urethroplasties or endoscopic interventions with multiple risk factors for further failure; such as radiation, hypospadias, lichen sclerosis, strictures >4 cm; the most suitable way to manage their urethral stricture and expectations may be to abandon further reconstruction and proceed with definitive urinary diversion.

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32.2.1 Pelvic Fracture Urethral Injuries

Failure of an end to end anastomosis after pelvic fracture urethral injuries (PFUI) is related to poor vascular supply and inadequate scar excision.

This is made worse with repeated attempted re-anastomosis as multiple surgeries can result in further ischemic injury, due to the loss of vascularity to the bulbar urethra. This lack of vascularity causes ischemia and necrosis of the bulbar urethra. Bulbar urethral necrosis is a devastating outcome, and a major reconstructive conundrum requiring multiple variable techniques to reconstruct as it represents the loss of the entire length of the bulbar urethra and its vascular supply. Outside of major reconstructive urology centers, these patients may be considered for urinary diversion.

32.2.2 Prostate Cancer Treatment

Prostate cancer is the second most common cancer in men worldwide, resulting in 1.3 million new cases in 2018 [4]. Curative treatment options include radiation (external beam radiation (EBRT), brachytherapy (BT), or a combination), radical prostatectomy, or combined therapy. All therapeutic options have potential short term and long-term complications including the development of urethral stricture disease.

The reported incidence of early urethral stenosis or stricture following radical prostatectomy may be higher (8.4%) compared to EBRT or BT (1.7–5.2%) [5], with population-based analysis demonstrating a high 10-year cumulative incidence of 19.3% for prostatectomy, 9.6% for EBRT, 11.94% for BT, and 19.4% for EBRT + BT [6]. While stricture and stenosis rates may be higher following surgery, radiation-induced strictures have high rates of urethroplasty failure (30.3%) [7].

Reconstruction of radiation strictures is associated with higher failure rates even in experienced hands due to the inherently poor tissue effected by the radiation treatment. Given considerations such as age, life expectancy with their prostate cancer, and other medical comorbidities, a urinary diversion may offer a more predictable outcome for these patients, with a better quality of life, and avoid multiple attempts at high risk urethroplasties.

Management of post-radiation strictures by repetitive endoscopic procedures, such as direct

vision internal urethrotomy (DVIU), TURP, and laser enucleation, can lead to the creation of difficult and devastating prostatic obliterative strictures, urethra-cutaneous fistulas, recto-urethral fistulas, osteitis pubis, and osteomyelitis of the pubic symphysis. The urethral tissue in these cases frequently is obliterative in nature associated with infection and inflammation. Attempted repairs of these devastating complications of radiation have success rates of 0–86%, dependent on the extent of the radiation damage and surgeon's experience [8]. Given the high rate of failure and increased complications from attempted repairs, such as fistula, devastation of the bladder neck, erectile dysfunction, and urinary incontinence; urinary diversion is often safer and offers a more predictable outcome.

Patients with radiation-related strictures may also develop a fixed prostatic or membranous urethra such that despite what appears to be an adequate lumen, they suffer ongoing obstructive symptoms similar to that of a tight urethral stricture. These patients may be offered repetitive dilations, DVIU, and TURP with no improvement in outcome due to the fibrotic nature of the urethra. For these patients, urinary diversion is a superior choice of treatment as repeated endoscopic interventions do not result in sustained improvement in symptoms but increases their risk of significant complications. The rigidity of the urethra and often the urinary sphincter can also lead to stress incontinence due to the inability of the sphincter to coapt. This may be further exacerbated following multiple endoscopic interventions where the sphincter is used as a fulcrum point due to the rigidity of the urethra. These patients may then develop the devastating outcome of incontinence and the inability to completely empty. Urinary diversion with a bladder neck closure could be considered in these instances to optimize their quality of life.

32.2.3 Urinary Prosthesis

Prostheses have been available since the early 1980s for both erectile dysfunction and urinary incontinence. Devices such as synthetic slings, artificial sphincters, or urethral compression

devices have been utilized, all of which have been associated with urethral strictures.

The Artificial Urinary Sphincter (AUS) has established itself as the gold standard for post-prostatectomy urinary incontinence. The most recent models have an associated infection and erosion risk of 8–9%. Erosion of the AUS can result in significant urethral tissue loss and subsequent stricture development.

For patients considering reimplantation of a urinary sphincter device following a previous complication, those with a history of radiation therapy, repeated treatment for bladder neck contractures, urethral stent placement, or previous device infection or erosion are at higher risk of repeat erosion and urethral loss. The outcomes of AUS or any newer compressive prosthesis following stricture treatment have not been extensively studied, however, what data there is demonstrates that re-implantation of the AUS does result in a higher rate of erosion than in a virginal implant [9, 10]. To avoid the cycle of urethroplasty, reimplantation, further erosion, and explantation, serious consideration for urinary diversion can be considered in these situations.

Urethral stents for stricture disease, such as the Urolume, have become unpopular due to concerns related to the extension of urethral stricture disease beyond the initial stricture site, fibrosis extension into the stent itself causing stent incorporation into the urethral wall, worsening of the inflammatory process with associated obstruction of the stent, haematuria and poor patient satisfaction. Potential urethral incorporation often requires more complicated procedures for Urethral stent removal, resulting in urethral tissue loss, and increased rates of urethroplasty failure, sometimes requiring urinary diversion for management [11].

32.2.4 Benign Prostatic Hyperplasia Treatment

Urethral stricture and bladder neck contractures are uncommon complications of BPH surgical management. Reported urethral stricture rates vary between energy sources from 1.4% up to

19% [12], while bladder neck contracture rates can be as high at 6.5%.

The traditional open simple prostatectomy has low rates of bladder neck contracture at 3.8% and urethral strictures up to 4.8%. The urethral stricture tends to occur in the urethral meatus which can be easier in the short term to manage.

Both monopolar and bipolar transurethral prostate resection is associated with bulbar and meatal stricture formation, with rates as high as 19% for bipolar TURP [12]. Risk factors that increase the rate of the stricture formation include increased operative time, larger prostates (>70 cc), surgeons experience, mismatch in size between urethral lumen and instruments, and insufficient insulation by the lubricant causing urethral thermal injury.

Bladder neck contractures are also an infrequent (5–9.7% [13, 14]) but bothersome complication of TURP. Factors that increase the risk of bladder neck contracture formation include circumferential resection, mechanical failure with stray current, urinary extravasation, ischemia from large urethral catheters, and infection.

Photovaporisation and Holmium laser enucleation have comparable rates of urethral stricture and bladder neck contracture to TURP, at 0.02% to 3.6% and 0% to 0.8% respectively [15–17].

Management of these complications is fraught with difficulties. One or two attempts at urethral dilation or urethrotomy can be considered in favorable stricture disease. However, patients with long strictures >2 cm and strictures located in the penile or membranous urethra have poor outcomes with repetitive dilation or urethrotomy, so should be considered for urethroplasty or urinary diversion. Many of these patients have had significant lower urinary tract dysfunction prior to their BPH surgical management and would prefer a definitive resolution to their difficulties, and a urinary diversion would offer this immediately for them.

32.2.4.1 Neurogenic Bladder and the Devastated Outlet

Refractory stenosis, urinary incontinence, or both can result from trauma, complications from surgeries or cancer therapies, or sequelae of neuro-

genic bladder dysfunction, and can be simplistically referred to as the devastated bladder outlet (DBO). Neurogenic bladder (NGB) patients, including those with spinal cord injury or myelomeningocele, are at risk for urethral disease secondary to frequent instrumentation and clean intermittent catheterization. DBO development in the NGB patient is a risk as the disease bladder may exhibit low capacity, high pressure storage, or an incompetent outlet, increasing risk for reconstruction failure. When reconstruction options are exhausted or ill-advised, urinary diversion with or without outlet closure may be indicated to provide continence and urinary quality of life.

32.3 Pre-Operative Evaluation

32.3.1 History and Examination

Male patients with an unreconstructable urethra are a heterogeneous group, with various etiologies represented.

A thorough history should be obtained, including characterization of both previous and current patient symptoms. A complete record of all previous surgical interventions may not be possible but will help with delineation of possible remaining salvage surgical techniques and consideration of risk factors for any diversion.

Patients with a history of urogenital malignancy should be evaluated for possible disease recurrence and life expectancy prior to undertaking any diversion. It is important to establish whether there has been previous radiation for any possible pelvic malignancy including rectal, cervical and urogenital as this will influence the choice of bowel segments for diversion, the possible need for cystectomy and the rate of complications following diversion. Reviewing comorbidities including simultaneous bladder or urethral fistula, ureteral stricture, hydronephrosis, chronic pelvic pain, or renal dysfunction preoperatively will influence whether a patient is a candidate for a bladder conserving approach to diversion.

Careful attention to rectal health, including the presence of simultaneous rectal pain, incontinence, or fistula, is an important consideration as

this may affect the patient's management goals and options.

An evaluation of a patient's performance status, including ability (dexterity and cognition) and willingness to perform intermittent catheterization or irrigation, is essential when deciding between a continent or incontinent diversion. A discussion of the potential effects of diversion on sexual health and fertility should be completed preoperative so patient expectations are clearly understood.

Abdominal examination should assess for previous abdominal scars and to determine appropriate stoma placement based on the patient's body habitus.

For patients with recent urethral reconstruction, dilation, or clean intermittent catheterization, a period of urethral rest with a suprapubic catheter to determine if urethral stenosis or stricture will redevelop should be considered. If complete urethral obliteration develops, the patient may not require bladder neck or urethral closure at the time of diversion.

32.3.2 Laboratory Evaluation and Imaging

Routine blood work including renal and liver function should be obtained as the use of bowel in bladder augmentation or urinary diversion may be contraindicated in patients with renal or liver dysfunction.

For patients with a history of or at risk for prostate cancer, PSA testing should be considered in order to ensure no latent or recurrent cancer is present.

Upper tract imaging should be obtained to determine the presence or degree of hydronephrosis or unilateral renal deterioration.

Cystourethroscopy can be utilized to determine if bladder tumors are present, especially in patients with a history of bladder cancer or previous pelvic radiation. Additionally, patency of the urethra and quality of the bladder can be reviewed by cystoscopy, as the presence of radiation necrosis or dystrophic calcifications may necessitate more extensive debridement or cystectomy at the time of diversion.

Urodynamic testing is essential in order to determine the patient's bladder capacity, continence status and the presence of detrusor overactivity. This essential information may indicate the need for simultaneous bladder augmentation, incontinent diversion or a bladder neck closure in the same surgical setting.

32.4 Continent Catheterizable Urinary Diversion

In motivated patients with good performance status who are free of contraindications such as, pelvic pain, fistula, renal dysfunction, hepatic dysfunction, or concurrent bowel disease (such as inflammatory bowel disease), continent urinary diversion can provide improved quality of life by allowing continence without the need for indwelling catheters or external drainage bags.

Principals of continent diversion include:

1. a reliable continence mechanism
2. an adequate volume
3. low pressure reservoir that avoids the use of synthetic materials
4. technically reproducible in construction.

If required, augmentation cystoplasty should be completed in the same operative setting.

Continent vesicostomy with an ileal channel is typically preferred in the adult patient for whom bladder preservation and continent catheterizable channel (CCC) is indicated, as other options may be limited by anatomic considerations.

While generally the preferred technique in children, Mitrofanoff appendicovesicostomy is usually impossible as the adult appendix is often surgically absent or inadequate secondary to limitations in length, lumen, or mesentery, especially in the obese patient.

The use of tubularized ileum with a Yang-Monti [18] or Casale (spiral Monti) [19] channel is more practical in the adult patient as adequate length to reach the abdominal wall is achievable. The Casale technique is most commonly required as it achieves a greater length when compared to the standard Monti and allows avoidance of

potential complications associated with bowel to bowel anastomosis requiring for a double Monti procedure, as per Figs. 32.1 and 32.2.

32.4.1 Monti and Casale Techniques

A 4 cm segment of ileum is isolated 10–15 cm proximal to the ileocecal junction. A slightly longer segment can be harvested if additional reach is required. If the patient's body habitus is such that length will not be an issue, a smaller segment can be harvested, detubularized along the midline length, and tubularized as a standard Monti channel. In the more typical Casale technique, the segment is marked in the midline and divided for approximately 80% of its circumference. Each of the two bowel rings are then incised just at the mesentery on opposite sides, leaving two strips of ileum. This Z-shaped strip is then tubularized with absorbable suture over a 14 French catheter with the resulting channel typically measuring 10–14 cm in length. The tube is tunneled in the bladder distally and a stoma is matured in the umbilicus or, if the distance is too far, the right lower quadrant.

Advantages of this technique include less concern about post-operative issues with gastrointestinal transit or malabsorption as the terminal ileum and ileocecal valve are left in continuity when compared with an ileal cecocystoplasty. Tunneling within the bladder is critical to facilitate continence of the tube, and the ends of the Casale or Monti tube are free to mesentery, facilitating easy tunneling and stoma maturation. However, care needs to be taken with thick hypertrophic bladders, as they tend to cause obstruction or kinking at the tunnel, making it difficult for the easy passage of the catheter.

32.4.2 Catheterizable Ileal Cecocystoplasty Technique

When a continent urinary diversion is indicated for patients with unreconstructable urethral disease, the “hemi-Indiana” catheterizable ileal cecocystoplasty (CICC) first described by Sarosdy in 1992 is an ideal option [20, 21]. This

Fig. 32.1 Casale or Spiral Monti catheterizable channel

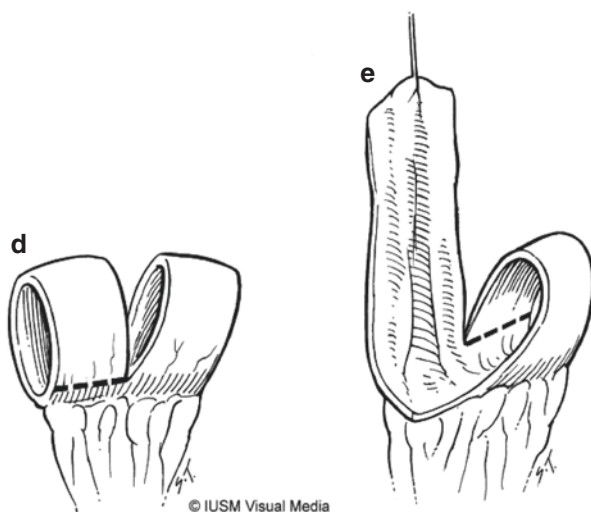
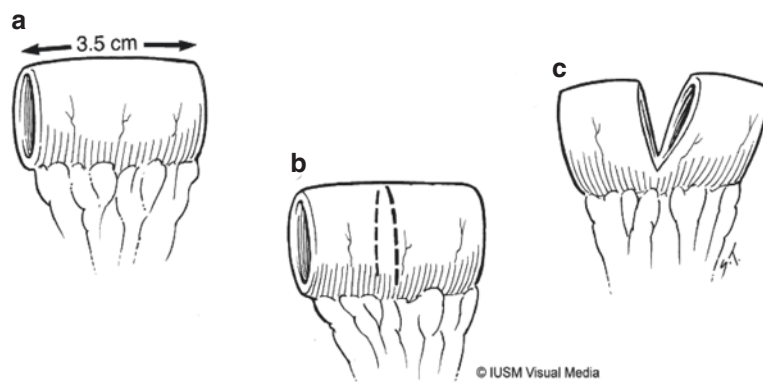
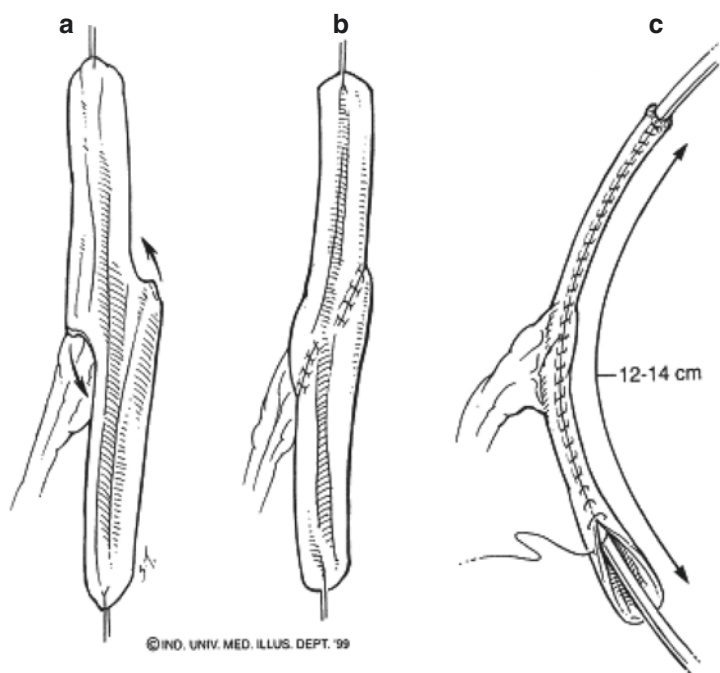


Fig. 32.2 Tubularization of spiral loop to construct the catheterizable channel



operation consists of simultaneous bladder augmentation with detubularized right colon and catheterizable channel creation using tapered terminal ileum. Thus, the continence mechanism is provided by the intact ileocecal valve.

An extended midline abdominal incision is made allowing the cecum and ascending colon to be mobilized. The bladder is divided in a clamshell fashion and 10–15 cm of ascending colon and 8–10 cm of terminal ileum are marked and staple divided. A side-to-side staple anastomosis of the ileum and ascending colon is performed using the GIA-100 stapler.

The colon is next detubularised 1 cm lateral to the taenia. The ileum is tapered over a 14 French catheter using linear staples. The valve may be reinforced with imbricating permanent sutures similar to an Indiana pouch procedure, but we now avoid placing these sutures as it is unclear if they improve continence but may result in difficulty with catheterization or kinking. The appendix is removed. The colon augment is anastomosed to the open bladder with absorbable suture, and the stoma is matured and brought to the skin at the umbilicus.

A minimally invasive approach to this operation has been described which includes ascending colon mobilization first using a hand-assist laparoscopic technique [22, 23]. The hand-assist port is then extended to a Pfannensteil incision for the anastomosis to the bladder and creation of the tapered ileal limb, allowing avoidance of a large midline incision.

A pouchogram can be considered at 10–14 days post-operatively, but we do not find this to be necessary. The indwelling catheter is removed, and patients may begin self-catheterization at 3 weeks. A suprapubic catheter is removed once efficient catheterization is ensured. A negative culture at this stage is mandatory since catheter removal may produce transient vesicoureteral reflux and febrile urinary tract infection can occur.

32.4.3 Continent Catheterizable Channel Outcomes

For functional and motivated patients with an unreconstructable urethra, a CCC may provide a

higher quality of life compared to permanent suprapubic catheterization or incontinent diversion requiring an external drainage bag [24]. Few series have addressed the outcomes of these operations in male patients diverted specifically for urethral pathology.

Reoperation rates in modern series of adult patients requiring CCC ranged from 12.9–50%, with most reoperations performed secondary to stomal complications [25–27]. Hadley et al. reported outcomes for 26 patients (6 male, 4 with a devastated bladder outlet) requiring Monti, double Monti, or Casale diversion for NGB [26]. Three of seven (43%) patients who underwent a double Monti were unable to catheterize secondary to stenosis of the channel, and this operation was abandoned in favor of the Casale technique later in the series. At 64 months follow-up, 19 patients (73%) were catheterizing through their stoma. Stomal stenosis, dehiscence, or necrosis was experienced by 1 patient each (12%).

Redshaw et al. compared 31 patients who underwent CICC to 30 patients with tunneled CCC using Monti, Casale, or double Monti techniques. The indication for surgery was NGB in 51 patients (84%) with the remaining patients requiring diversion for unsalvageable urethral problems or bladder neck stenosis. They found more tunneled CCC patients (50%) required a secondary operation for channel problems compared to the CICC group (13%, OR 6.4, 95% CI 1.8–28) at an equivalent 16 months of follow-up [27]. A difference in stomal revision remained significant when CICC was compared to the subgroup of tunneled CCC patients who underwent simultaneous bladder augmentation (46.7%, OR 4.2, 95% CI 1.1–19.6). An initial stomal leakage rate of 29% was observed in the CICC group compared to 43% of the tunneled CCC group ($p = 0.12$), but the authors report leakage was resolved in most patients (93.5% with CICC and 77.7% for other channels) with catheterization regimen adjustment and anticholinergic therapy.

The authors recognize that low rates of stomal stenosis and revision following CICC may be secondary to short follow-up in this group [27]. Khavari et al. reported stomal stenosis in 3 of 34 CICC patients (9%) compared to 1 of 31 patients

(3%) in the Redshaw et al. series [25]. A stomal continence rate of 91% was reported in this series which is similar to the final 93.5% reported by Redshaw et al. These rates compare favorably to a 65% continence rate reported by Van der Aa et al. in their series of 34 adult NGB patients who underwent tunneled CCC [28].

Utilization of tapered ileum during CICC allows for a longer channel compared to detubularized ileum, which may be limited to a 10–14 cm length, possibly resulting in tension on the stoma in obese patients. Hadley et al. recognized in their study that stomal complications were more common in patients with higher body mass index. Additionally, there may be risk of devascularization of the ends of the detubularized ileal channels as the mesentery to the segment is small, limited to the original length of bowel that is harvested.

These reviewed series are primarily composed of NGB patients with urethral indications for CCC observed in only 0–16% of included patients, with concomitant outlet procedure with bladder neck closure (BNC) or AUS performed in 24% of the patients in Khavari et al. and 58% in Hadley et al. [25–27] Therefore, the results may be difficult to extrapolate to the male patient with unreconstructable urethral disease typically related to radiation therapy or multiple previous lower urinary tract operations.

Complication rates in series of CCC patients with simultaneous BNC may better represent expected outcomes. Stomal stenosis was reported in 3 of the 12 patients (25%) with a devastated bladder outlet (DBO) requiring BNC and a tunneled CCC in the series by O’Conner et al. [29] Shpall et al. and Spahn et al. similarly reported stomal revision after BNC and CCC in 5 of 19 patients (26%) and 4 of 15 patients (24%), respectively [30, 31]. These results are also consistent with a stomal stenosis rate of 27% reported in the series of 11 patients who underwent BNC and CCC following salvage prostatectomy [32]. Of note, CICC was not performed in any of these patients while appendicovesicostomy was commonly utilized, potentially accounting for a higher stomal complication rate.

Overall, post-operative complication rates were high (31–54%) in these series which

included an abdominal operation for a continent catheterizable channel [25–27, 30], with higher complications being reported in patients requiring bladder augmentation (47–54%) compared to CCC alone (33%) [25, 27].

32.4.4 Simultaneous Augmentation Cystoplasty with CCC

Spahn et al. reported stomal incontinence in 3 of 17 patients (18%) who underwent BNC and CCC with Mitrofanoff or ileal intussusception valve [31]. Their report of DBO patients included 13 males, including ten with a history of prior radical prostatectomy. In their series, only patients with a pre-operative bladder capacity less than 300 ml underwent simultaneous ileal bladder augmentation. They noted that following BNC, six of the eight patients (75%) who did not undergo augmentation required anticholinergic therapy, of whom three developed stomal incontinence. They theorized that BNC is associated with a post-operative loss of bladder capacity and reported two of the three patients were noted to have resolution of their stomal incontinence following delayed bladder augmentation. The authors ultimately concluded that augmentation should be considered in all patients requiring BNC for a DBO.

These results are corroborated by De et al. who remarked that previous patients who underwent salvage prostatectomy with BNC and CCC experienced persistent urgency, low capacity, anticholinergic requirement, and a frequent catheterization interval, and as such shifted their practice to performing routine bladder augmentation in all future patients with BNC in this setting [32, 33]. Pre- and post-operative urodynamic studies of the 34 patients who underwent CICC augmentation in the Khavari et al. series revealed a median increase in bladder capacity of 205 ml [25]. This increased capacity may allow for a longer necessary interval between catheterizations and therefore an improved quality of life in these patients, which must be weighed against the increased morbidity and complication potential following augmentation. Preoperative evaluation

of the patient's bladder capacity is essential, with consideration that capacity may be further diminished following BNC.

It is our bias to perform augmentation cystoplasty in all patients requiring BNC and continent diversion for unreconstructable urethral disease, with rare exceptions such as in patients with large capacity bladders noted on urodynamics studies. Failure of the bladder neck closure or diversion can be secondary to imperfect surgical technique, unfavorable local tissues, or high pressure, small capacity bladders, and therefore augmentation in addition to aggressive anticholinergic therapy is the standard approach to these patients.

32.5 Bladder Neck Closure

For patients with the combination of an unreconstructable urethra and confirmed stress urinary incontinence, simultaneous bladder neck closure (BNC) could be considered as a concurrent procedure with bladder-preserving urinary diversion.

BNC permanently removes the ability to obtain bladder drainage via urethral catheterization in the setting of acute urinary retention, a significant risk in patients with a continent diversion who may develop stomal stenosis or occlusion. As such, BNC should be considered a procedure of last resort to improve urinary incontinence in patients who are otherwise without another reconstructive option.

32.5.1 Transvesical Bladder Neck Closure Technique

In patients, without a history of radiation therapy, we prefer the transvesical bladder neck closure (TBNC) technique as described by Reid et al. [34] An infraumbilical midline or Pfannenstiel incision is made. A transverse incision is made in the bladder dome allowing adequate exposure of the trigone.

Electrocautery is used to dissect free a circumferential cuff of the bladder neck and prostatic urethra. The urethral side of the cuff is then closed

with interrupted figure-of-eight stitch using 2-0 polyglycolic acid sutures. Apposition of the denuded bladder neck muscle and prostate tissue is performed using a purse-string 2-0 polyglycolic acid suture forming a second layer of closure over the first. The bladder mucosa is then similarly closed as a third layer taking care not to compromise the ureteral orifices, as in Fig. 32.3.

The benefits of the TBNC compared to a retropubic technique includes significantly less pelvic dissection decreasing operative time, blood loss, and the risk of adjacent organ injury.

32.5.2 Retropubic Bladder Neck Closure Technique

While increasing operative time and potential for blood loss and morbidity, the retropubic (RBNC) technique allows for cephalad mobilization of the bladder from the urethral stump and for tissue interposition and is therefore preferred in patients with previous radiation therapy, prior failed BNC, or other risk factors for failure.

The patient is positioned in a slightly hyperextended Trendelenburg position. The retropubic space is entered via a midline abdominal incision that can be extended cephalad if a diversion or augmentation is also planned. The bladder is mobilized by dividing the urachus and lateral pedicles in an approach similar to cystectomy. The dorsal venous complex, if intact, is a potential source of bleeding and is ligated. A vertical cystotomy is then made 1–2 cm cephalad to the bladder neck to allow visualization of the trigone.

The ureteral orifices are then stented with 5 French feeding tubes to facilitate visualization throughout the closure. The bladder neck is divided using cautery. Grasping the posterior bladder neck edge with Allis clamps allows cephalad mobilization of the bladder. A plane between the bladder and rectum is developed along Denonvilliers' fascia. Development of this space allows cephalad mobilization of the bladder neck away from the urethra.

The bladder neck is closed with interrupted 2-0 polyglycolic acid sutures with a second layer of closure utilized to imbricate the first closure

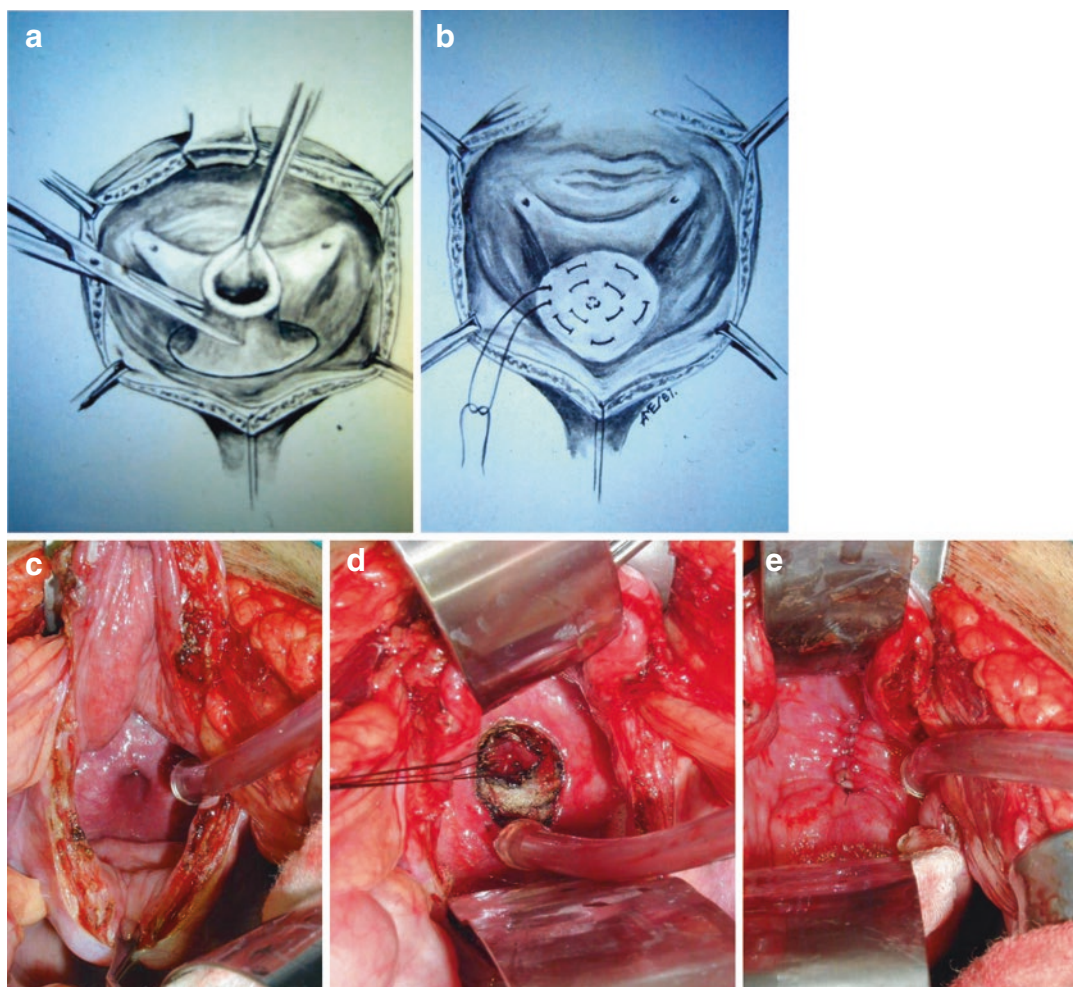


Fig. 32.3 Transvesical bladder neck closure. The bladder is bivalved and the bladder neck excised (a) and closed in 3 layers (b–e). Reid et al. [43]

layer. If feasible, the urethra is closed in an interrupted fashion. In patients with a history of radiation, excellent hemostasis and care not to enter the rectum are essential.

In patients without a history of radiation therapy or previous BNC failure, we do not feel tissue interposition is essential but may be performed to reduce the risk of vesicourethral fistula. If entry into the abdomen is planned for urinary diversion creation, an omental flap is a reasonable source for interposition. A flap of omentum is mobilized along the left or right gastroepiploic artery and draped over the pelvic floor with interrupted suture, separating the urethral stump from the closed bladder neck. If urinary diversion will be achieved with a suprapubic catheter (SPC) alone

and entry into the abdomen is not planned, a pedicled rectus abdominis muscle flap can provide a well vascularized interposition [35].

In patients whose prostate remains *in situ*, dissecting the bladder neck proximal to the prostatic urethra can allow for continued fertility and sexual function in a young male who desires this. If the prostate is planned to be left *in situ* the patency of the urethra must be investigated. If complete urethral obstruction distal to the prostate is observed then there will be no outlet for prostatic secretions, which can lead to pain or problematic fluid collection over time. Salvage prostatectomy should also be considered at the time of BNC in patients with previous radiation therapy for prostate cancer and may be performed

to additionally provide distance between the closed bladder neck and urethra.

32.5.3 Bladder Neck Closure Outcomes

Success of the BNC specifically relies on the technique's ability to prevent vesicourethral fistula formation. There are few reported series on the success of BNC in male patients, and fewer specifically reporting in those with refractory urethral disease.

Reid et al. first described TBNC reporting success in 4 of 6 male patients (67%) who underwent simultaneous continent vesicostomy for neurogenic bladder (NGB) [34].

Many of the modern RBNC series report male and female success rates of 83–100% [29–31, 36, 37]. Spahn et al. reported a 0% vesicourethral fistula rate following RBNC with omental interposition and continent vesicostomy at 68 months follow-up in 17 patients (13 males) [31]. They attribute their success to meticulous hemostasis, cephalad mobilization of the bladder, and tissue interposition. Kranz et al. similarly reported 100% success in 15 patients (5 with a DBO) following a 2-layer RBNC with omental interposition, augmentation, and continent ileovesicostomy at 24 months follow-up [37].

Vesicourethral fistula is a risk following BNC, and Shpall et al. reported a 15% failure rate in their series of 39 NGB patients at 37 months follow-up [30]. Patients in this series, including 29 male patients and 9 patients with previous urethral surgeries, underwent RBNC with omental interposition and simultaneous ileovesicostomy or continent diversion.

O'Conner et al. reported a 17% failure rate of BNC in 35 complex DBO patients (24 males, 3 with post-prostatectomy complications) at follow-up of 79 months, potentially indicating that the fistula rate may be higher in patients requiring RBNC for urethral indications [29]. All patients underwent RBNC with omental interposition and various forms of urinary diversion, including SPC alone in 15 patients. Of the 6 failures, 4 underwent a successful second transabdominal procedure.

Colli and Lloyd reported a 9% vesicourethral fistula rate in their unique series of 11 male NGB patients, of whom 7 required previous urethral

dilations [36]. All patients underwent a RBNC without tissue interposition and permanent SPC diversion. All patients had pre-operative UDS testing revealing a bladder capacity >125 ml and none had previous radiation therapy. The comparable outcomes in this series supports the practice of not routinely providing tissue interposition during BNC in this select patient population.

No injury or deterioration of the upper tracts was observed in follow-up in any series, although this was not consistently reported. Although use of anticholinergic therapy was not routinely discussed in these series, we consider this to be mandatory when BNC is performed for patients with an unreconstructable urethra. A history of radiation therapy or previous surgery to the lower urinary tract was also inconsistently reported, and the success observed in these series may not be representative in the complex male patient with unreconstructable urethral disease.

32.5.4 Simultaneous BNC Following Salvage Prostatectomy

BNC with augmentation cystoplasty and/or urinary diversion is a controversial approach to lower urinary tract reconstruction in the patient requiring salvage prostatectomy. As incontinence rates following salvage prostatectomy are very high, even when AUS is ultimately utilized, this approach may allow for simultaneous treatment for an almost inevitable complication. Reported series involving a complex patient population with a 100% rate of radiation therapy prior to BNC showed acceptably low rates of vesicourethral fistula formation, indicating BNC success can be achieved in even complex patients requiring BNC for unreconstructable urethral disease.

Pisters et al. first reported outcomes for patients who underwent BNC and continent urinary diversion at the time of salvage prostatectomy for local prostate cancer failure following radiation therapy [33]. The initial series of 12 patients underwent BNC following retropubic salvage prostatectomy, which included wide bladder neck and membranous urethral excision, including surrounding skeletal muscle, in order to achieve surgical margins. Omental interposition and continent

diversion were performed without augmentation. Four patients (33%) required reoperation including 1 patient (8%) with a vesicourethral fistula who ultimately required cystectomy.

Ullrich and Wessels described a technique following salvage retropubic prostatectomy in which a segment of small or large bowel can be anastomosed to the widely opened bladder neck, allowing simultaneous bladder neck closure and augmentation [38]. This technique may be useful for BNC when extensive necrosis of the prostate is present and significant debridement of the bladder neck is required. The use of bowel interposition allows for tension-free closure of a large bladder neck defect in these cases, and the presence of the bowel mesentery creates its own tissue interposition between the bladder neck and urethral stump. All five men in this series were without vesicourethral fistula formation (100%) at a mean follow-up of 6 months, although 1 patient required exploratory laparotomy for bladder rupture at 4 months post-procedure and another experienced stomal stenosis.

32.5.5 Urethral Closure with Suture Ligation

As an alternative to BNC, permanent urethral closure is an emerging option to achieve continence in patients with an unreconstructable urethra and incontinence. With appropriate pre-operative counseling, this procedure can be considered as an alternative at the time of attempted reconstruction or salvage of a challenging urethral operation. The most likely scenario for urethral ligation to be considered is at the time of AUS explant in a patient with multiple previous urethral operations or cuff erosions who may be a poor candidate for urethroplasty and eventual device reimplantation, potentially avoiding months of urinary incontinence while a definitive operation is planned.

To perform a permanent suture urethral ligation, a perineal incision is made and the bulbar urethra is circumferentially dissected and divided at or near the bulbomembranous junction. The mucosa of the proximal and distal urethra is oversewn with 4-0 poliglecaprone suture, with multi-

ple figure-of-eight sutures used to invert the proximal urethral stump. The stump is secured to deep perineal tissue and layers of tissue, including bulbospongiosus muscle, is interposed.

This procedure is advantageous in that it reduces operative time and morbidity from abdominal surgery in patients who will be diverted with an SPC. Quality tissue interposition is limited, but outcomes may be improved by coverage with spongiosum applied as a rotational flap if the local tissues are of good quality [39].

There exist only limited series reporting outcomes following urethral ligation, however, high success rates have been reported. Higutchi et al. reported on an adult series of 6 urethral ligation patients with 1 reported failure (17%) in a patient with a history of pelvic radiation who experienced post-operative urethral incontinence [39]. A high success rate (100%) was achieved in another series of four young men, all of whom had a history of ileocystoplasty and continent catheterizable channel (CCC) for myelomeningocele [40]. Three of the patients had a history of autologous fascial sling for persistent urethral incontinence following CCC diversion, and success was reported at a follow-up of 49 months.

VanDyke et al. reported outcomes of urethral ligation with concurrent SPC diversion in a series of 10 adult men with end-stage urethral disease [41]. Nine men (90%) had a prior AUS implantation, three (30%) had prior radiation therapy, and a median of 4 prior urethral surgeries was reported among all the men, including 5 patients (50%) with prior urethroplasty. Four patients (40%) developed refractory bladder spasms of whom 2 (20%) developed a urethrocuteaneous fistula, and an additional 2 patients (20%) developed a post-operative abscess. Ultimately 70% of patients were dry at a median follow-up of 12 months – one patient required cystectomy, one became dry after a salvage urethral closure, and a third patient had a small persistent fistula despite a second operation.

Complications including persistent urinary incontinence and fistula formation are not uncommon following urethral closure with suture ligation. Therefore, it should be considered a last resort option when an abdominal operation for BNC is ill-advised due to the high risk of intra-

operative and post-operative morbidity, in patients with persistent stress urinary incontinence and/or urethral leakage despite previous surgery for urinary diversion.

Aggressive medical management of bladder spasm with anticholinergic therapy is mandatory in all patients undergoing bladder neck or urethral closure. Simultaneous bladder OnabotulinumtoxinA injection may also be considered to help improve outcomes, especially in patients with a small capacity bladder.

32.6 Incontinent Urinary Diversion

For patients with an unreconstructable urethra who are unsuitable for diversion with continent catheterizable channels; incontinent urinary diversion remains an option with good quality of life outcomes. Patients that are not suitable for continent urinary diversion typically are those with pathology which requires concomitant cystectomy, failure of the catheterizable channel or catheterization difficulty, or persistent incontinence following bladder neck closure.

Incontinent urinary diversion options are diverse and include ileovesicostomy or ileal conduit diversion, or less commonly, cutaneous ureterostomy or ureterosigmoidostomy. The benefit of reservoir formation over cutaneous ureterostomy is the reduced risk of stomal stenosis and subsequent urosepsis or upper tract deterioration. This is especially the case for patients with a benign indication for diversion who often have a long life expectancy. Ureterosigmoidostomy was a common technique for urinary diversion in the early twentieth century but is now less commonly utilized due to concerns with recurrent infections, worsening renal function, metabolic abnormalities, or malignancy [42, 43].

32.6.1 Suprapubic Catheter Placement

For patients that would prefer a simple intervention or are not medically fit enough for a larger reconstructive procedure, a suprapubic catheter

(SPC) is an acceptable option acknowledging the requirement for a catheter tube and bag.

In patients with no previous abdominal surgeries, a bladder capacity of greater than 300 mls, an SPC can often be placed with endoscopic guidance (cystoscopy and insertion), avoiding the need for an open cystotomy placement. An ultrasound may be utilized to determine if bowel loops are overlying the bladder prior to puncture with an SPC trocar, to decrease the risk of bowel injury. In patients with previous abdominal surgeries, increased abdominal girth/BMI, ultrasound is essential when relying on trocar SPC technique to avoid bowel injury. Open cystotomy is recommended for safe access if the bladder capacity is small or there is bowel overlying the bladder.

Long term suprapubic catheter usage is generally well tolerated. A review by Hunter et al. found that most patients become more optimistic regarding their need for catheterization over time [44]. “Satisfaction” rates of 52–72% are reported in quality of life studies despite the high complications rates associated with long term catheterization [45, 46]. Bacteriuria is inevitable and commonly leads to urinary tract infections in patients with long term catheterization. Katsumi et al. reported long term SPC outcomes for male spinal patients. In their cohort of 46 patients, 11% developed urosepsis and 30% of patients developed >1 UTI per year. 2 (4%) patient deaths resulted from urosepsis [47]. Bladder stone and neoplasia occurrence from long term catheterization increases with the duration of catheter use and study follow up duration. The incidence of bladder stone formation is estimated to be 25% at a mean of 50 months, and close to 50% by 20 years [48]. Rates of catheter-related squamous cell carcinoma are estimated to be 0–2.2% [49].

32.6.2 Ileovesicostomy

Ileovesicostomy provides a relatively simple approach to incontinent diversion that retains the native bladder function and innervation, preserves the native trigone, and maintains sexual function. It is associated with less operative morbidity than other supravescicle diversion

approaches as cystectomy, ureter mobilization, and ureteroileal anastomosis is not required. Additionally, the anti-reflux mechanism of the native ureter is preserved. Ileovesicostomy is unique in that it preserves the native urinary tract and is therefore reversible were the patient to experience poor functional outcomes that may later be managed with another diversion technique [49, 50].

Ileovesicostomy was first described by Smith and Hinman in 1955 in canine models [51]. This was shortly followed by the first ileovesicostomies in humans in 1957 by Cordonnier [52]. The contemporary technique stems from the work of Schwartz et al. [50] with several authors (Rivas [53], Mutchnik [54], Gudziak [55], Gauthier [56]) making iterations to the technique since. Principally described for the management of patients with neurogenic bladders who cannot be managed with intermittent self-catheterization, ileovesicostomy is also a recognized option for patients with intractable lower urinary tract dysfunction or a DBO [57].

32.6.2.1 Ileovesicostomy Technique

The primary aim of ileovesicostomy is to provide a low-pressure conduit for urinary diversion; to achieve this, four primary principles are followed:

- (i) Wide-mouthed vesical anastomosis
- (ii) Avoidance of limb redundancy to avoid urine pooling and metabolic disturbance
- (iii) Adequate fascial window
- (iv) Adequate stoma siting/formation.

Open, laparoscopic, and robotic approaches have been described.

Open Approach

The procedure can be performed under general or regional anesthesia. Some series advocate for the use of mechanical bowel preparation and prophylactic intravenous antibiotics on the day of surgery [54, 58].

The patient is positioned prone. A midline or transverse incision is made to access the abdominal cavity. A segment of terminal ileum is then

isolated with its vascular pedicle. A 15 cm segment is usually adequate to achieve a sufficient conduit, taking care to reduce conduit redundancy. A longer length may be required for larger patients with a thicker abdominal wall [53, 55]. Bowel continuity is then re-established with a side to side anastomosis.

The bladder is then mobilized. An incision is made to widely open the bladder dome, as in Figs. 32.4 and 32.5. This can be a transverse incision or a U-shaped posteriorly based flap on the right superolateral aspect of the bladder [55]. The ileal segment is then detubularised along the antimesenteric border for spatulation and anastomosis with the bladder. A circular anastomosis is avoided to reduce the risk of stenosis. A 6–9 cm segment of intact bowel is left to fashion the stoma [56].

The ileovesical anastomosis is made using a continuous 2-0 absorbable suture. Rivas describes a modified Boari flap for both ends of the anastomosis [53]. A Malecot suprapubic catheter or urethral catheter is placed to maximize bladder drainage.

The stoma is matured as an end-on or Turnbull loop stoma in the right lower quadrant taking care to reduce conduit redundancy. A pelvic drain is placed and several authors describe placing a 20–22 Fr catheter via the stoma [53, 56,

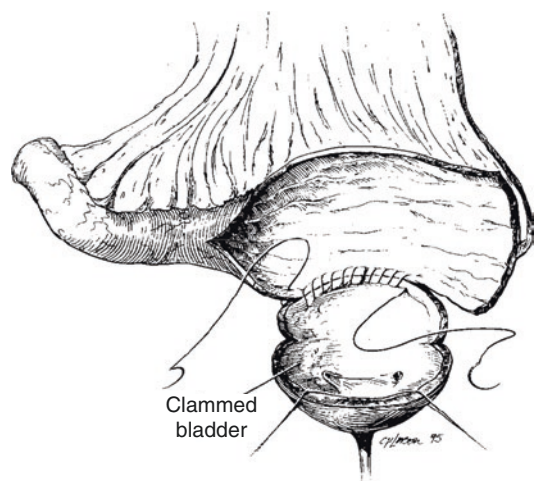


Fig. 32.4 Formation of ileovesicostomy, including generous transverse cystostomy and detubularization of ileal segment. Mutchnik et al. [54]

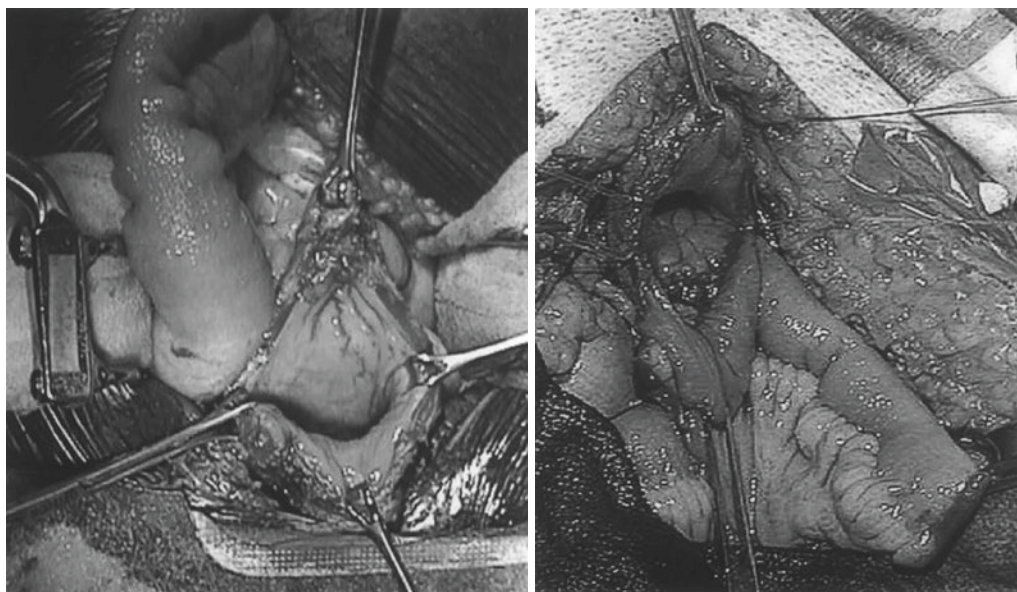


Fig. 32.5 Wide transverse cystotomy at the bladder dome [56]

[58, 59]. Most series describe the placement of a nasogastric tube which is most helpful for patients with concomitant neurogenic bladder and bowel dysfunction.

Post-operatively, the pelvic drain and SPC can be removed within 24–48 hours provided there is no evidence of urine or anastomotic leakage. A cystogram can be performed to ensure successful ileovesicostomy anastomosis prior to removal of the stoma catheter. The reported post-operative duration prior to cystogram ranges from 1–4 weeks [53, 54, 58, 60]. Leng et al. advocated for routine stoma irrigation to prevent mucus plugging in the early post-operative period [60].

Laparoscopic Approach

Two case reports describe the laparoscopic approach which utilizes the same surgical principles as the open approach. Hsu et al. described a transperitoneal, 5 port, extra-corporeal bowel harvesting approach in 2002, as per Fig. 32.6 [61]. Operative time was 4 hours, with an estimated 100 ml blood loss. Abrahams et al. described a 4 port, transperitoneal, intra-corporeal bowel harvest approach in 2003 [62]. A vertical cystotomy was created and neither the bowel or the bladder

was spatulated. The stoma was matured at the single 12 mm port side. Operative time was 4.5 hours, with an estimated 50 ml blood loss. No significant intra-operative or post-operative complications were recorded in either report. Long term outcomes were not reported.

Robotic Approach

Small retrospective series using robotic assisted techniques have been reported by Vanni et al. and Dolat et al. [63, 64] Port placement is as shown in the Fig. 32.7 below. The series included 9 and 4 patients, with mean operative times of 330 min and 290 min and estimated blood loss of 100 ml and 130 ml respectively. Median follow up duration was 14 and 25.8 months respectively. No major intraoperative complications were reported. All patients achieved low pressure drainage with only 1 patient eventually having an ileal conduit due to patient preference as they had high residual volumes of approximately 300 ml post-operatively.

Ileovesicostomy Outcomes

Ileovesicostomy offers a relatively simple urinary diversion approach and avoids the many complications observed with other supravescical

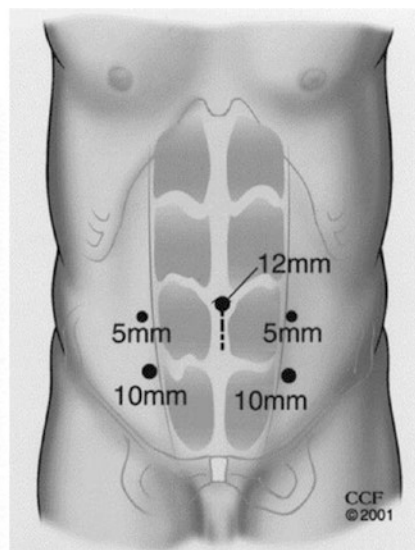
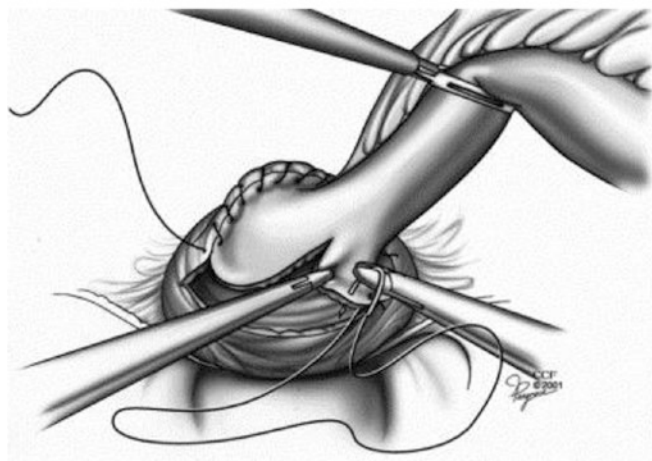


Fig. 32.6 Demonstration of ileovesical anastomosis with spatulated proximal ileal end and laparoscopic port site placement. Hsu et al. [61]

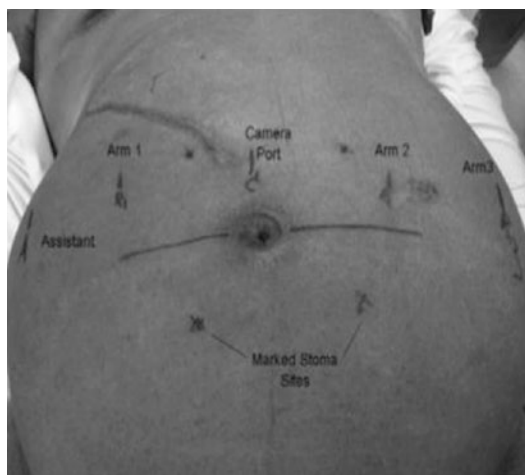


Fig. 32.7 Demonstration of port site placement of robotic assisted approach. Vanni et al. [63]

urinary diversion techniques due to the preservation of a functional bladder. Reported series predominantly describe long-term outcomes for patients undergoing ileovesicostomy for uncontrolled NGB. While patients with an unreconstructable urethra likely have different underlying pathophysiology and comorbidities, long term expected outcomes can be inferred from these series.

No major intraoperative complications were reported in any series. Post-operative complications are largely categorized into abdominal surgery related complications and urinary tract and conduit related complications (Table 32.1).

Low pressure urinary drainage (<40 cm H₂O) with low residual volumes (<100 ml) were achieved in $>90\%$ patients who predominantly had a neurogenic bladder (NGB). Patients who have residual volumes of >100 ml tended to have pre-existing hypotonic or atonic bladders and were managed with catheterization post-operatively [54].

Secondary malignancy risk is very low and has generally been attributed to prior long-term catheterization in the NGB population. In the series by Leng et al., 2 of 38 patients (5.2%) developed malignancy – urothelial carcinoma and squamous cell carcinoma at 38 and 39 weeks follow-up respectively [60]. Tan et al. advocated for cystoscopic surveillance after 3–5 years following surgery to monitor for malignancy [58]. No conduit related malignancy has been reported.

High overall patient satisfaction was reported by Gauthier et al. [56], consistent with the observation that very few patients required progression to suprapubic urinary diversion or reversal of ileovesicostomy in other series.

Table 32.1 Ileovesicostomy complications and outcomes

Series	N	Follow-up (mean months)	General complications (%)			Urinary tract complications (%)			Conduit related complications (%)	
			Wound infection	Cardiorespiratory complications	Ileus	Bowel obstruction	UTI/ Urosepsis	Calculi	Stomal	Anastomotic stricture
Vanni et al. [63]	15	13–15	1 (7)	4 (26)	3 (20)	1 (7)	7 (47)		2 (13)	
Zimmerman and Santucci [57]	8	28.4	–	–	2 (25)	–	1 (12.5)	–	–	–
Hellenthal et al. [65]	12	66	–	–	2 (17)	–	8 (67)	5 (42)	1 (8)	
Tan et al. [58]	50	26.3	17 ^b (34)	–	–	13 ^a (26)	5 (10)	4 (8)	28 (56)	2 (4)
Gauthier and Winters [56]	7	37.4	1 (14)	–	2 (29)	–	2 (29)	1 (14)	1 (14)	–
Leng et al. [60]	38	52	2 (5)	–	–	1 (3)	1 (3)	6 (16)	7 (18)	1 (3)
Gudziak et al. [55]	13	23	1 (8)	–	2 (15)	–	1 (8)	1 (8)	2 (15)	–
Atan et al. [66]	15	23.2		2 (13)	2 (13)	2 (13)	3 (20)	5 (33)	2 (13)	–
Mutchnick et al. [54]	6	12–15	–	–	–	–	1 (17)	–	–	–
Rivas et al. [53]	11	24	–	–	–	–	–	–	–	–

Calculi complications include both upper tract and bladder urolithiasis
Stomal – include stomal/fascial stenosis, stomal prolapse, ileal limb kinking/obstruction and hernia
^aIncludes ileus and small bowel obstruction
^bIncludes 13 superficial wound infections and 4 deep wound infections leading to peritonitis

Ileovesicostomy Failure

Unsuccessful urinary diversion via ileovesicostomy may be caused by mechanical obstruction, recurrent urinary tract infections, and urolithiasis formation, necessitating revision surgery or progression to an ileal conduit.

Recurrent urinary tract infections are predominantly secondary to high post-void residual urine volumes, ileal limb obstruction, or urolithiasis [67]. Rates of revision surgery to manage stomal or conduit related mechanical obstruction is significant, with rates as high as 28% reported by Tan et al. [58]

Assessment includes cystoscopic evaluation of the conduit and native bladder, radiographic imaging to assess for urolithiasis and strictures, and urodynamic studies to evaluate the position of mechanical obstruction. A detrusor leak point pressure of >20 cm H₂O strongly suggests obstruction [67]. A urodynamics catheter is passed via the stoma into the bladder, which is slowly filled. Once a leak point pressure is confirmed, the catheter is slowly removed under image guidance to locate the site of obstruction.

Management is guided by the underlying etiology. Intermittent catheterization is recommended for post-void residual volumes >100 mls [67]. Flushing of the conduit can be helpful to clear any mucus build up which may also predispose patients to stone formation. Lithotripsy of urolithiasis is recommended to remove any nidus of infection, although it is noted that retrograde urethral access will be difficult in this patient population.

Patients who have recurrent urinary tract or conduit related complications can be offered supravescical urinary diversion. This is a rare occurrence, with only a handful of patients from the above series needing to proceed to an ileal conduit. The reasons for these were related to either recurrent stone formation with urinary tract infections or the development of fistula disease in patients with NGB and previous long-term catheter use. One patient elected for ileal conduit due to high post-void residual volumes [68].

32.6.3 Ileal Conduit

Conduit diversion is rarely indicated but serves as an option of last resort for the management of patients with a DBO, especially when there are concomitant pathologies affecting the lower urinary tract necessitating removal of the bladder.

Technically, any segment of bowel can be used for conduit diversion, but the most commonly utilized segment is the ileum, as described by Bricker (1950). This diversion is widely utilized by urologists and the technique will not differ for the population of patients addressed in this chapter [69].

32.6.3.1 Ileal Conduit Outcomes

Long term outcomes are well described for conduit diversions for malignant disease, but series for benign pathologies are more limited. Despite being less surgically invasive, overall complications rates for simple cystectomy are comparable to radical cystectomy (60.4% vs 57.7%, $p = 0.3$) [70]. This is possibly due to differences in underlying patient population characteristics such as higher rates of pre-existing infection and comorbidities such as spinal cord pathologies or previous radiation therapy.

Aisen et al. in 2017 reported the largest analysis of early postoperative outcomes for simple cystectomy patients, using NSQIP data from 2005–2014 [70]. In 389 patients, the overall complication rate was 60.4%. 39% required blood transfusion within 72 hours, 31% had infectious complications, and 5.7% required reoperations. The mortality rate was 1.3%, involving 5 patients.

Osborn et al. in 2014 reported another large series from 2003 to 2012 involving 139 patients with a median follow up period of 13 months [71]. Four patients underwent surgery for urethral stricture disease. 53% underwent supratrigonal cystectomy, 29% underwent subtrigonal cystectomy, and 18% underwent cystoprostatectomy. Supratrigonal cystectomy was associated with less blood loss than subtrigonal cystectomy and cystoprostatectomy (400 vs 567 ml, $p = 0.01$). Operative times were not significantly different. Overall, 67% of patients experienced complications, with 57% of patients having a Dindo-Clavien >2 complication

and 35% of patients experiencing multiple Dindo-Clavien 1 complications. 20% of patients had ileus and one death was reported.

Despite the high peri-operative complication rates, good functional outcomes were reported, with 99% of patients having a resolution of their pre-operative pathology [71]. This is consistent with the findings from Al Hussein Al Awamlh et al. and Cheng et al. [72, 73]

Longer term complications are less well defined. Stoma complications including stenosis and parastomal hernia range from 4–13% [74–76]. Urostomy related complications including leakage and skin irritation range from 2–8% [74, 77]. Ureteroenteric stricture rates range from 4–9% [26, 33, 35, 71, 75, 78]. Urolithiasis is reported in 1% of patients and urosepsis in 9–22% [70, 71, 75].

Concomitant Cystectomy

Concomitant cystectomy with urinary diversion is debated and patient counseling involves balancing the risks of complications associated with a retained bladder and the increased morbidity from cystectomy. Brown et al. investigated recent trends in the USA in their 2016 retrospective review of conduit surgery for benign pathologies, in which 27% of patients underwent concomitant cystectomy and 73% underwent urinary diversion alone [76]. A small trend toward concomitant cystectomy was seen in patients who were Medicare insured or treated in a teaching hospital over the period from 1998 to 2011.

Several authors advocate concomitant cystectomy to avoid complications of the retained bladder, with rates as high as 60% reported secondary to conditions such as pyocystitis, secondary carcinoma, hematuria, and pain [77, 79]. A more contemporary series by Lawrence et al., however, reported significantly lower rates of complications with only 4 of 60 patients (7%) experiencing complications specifically arising from a defunctionalized bladder [74].

No dedicated series have been reported for unreconstructable urethral disease as the primary indication for urinary diversion. However, Engel et al. and Eigner et al. both reported high compli-

cations rates in patients with defunctionalized bladders with more distal obstruction [80, 81]. Engel et al. reported a 43% secondary cystectomy rate and Eigner et al. reported a 71% complication rate with 43% patients requiring further operations. These series may support concomitant cystectomy in this specific patient population.

Few case reports of adenocarcinoma from retained bladders have been reported, leading to some authors to advocate for screening for bladder malignancy [82]. It is noted, however, that none of the larger series have reported any secondary malignancies.

32.6.3.2 Simple Cystectomy Technique

Simple cystectomy refers to the surgical removal of the bladder for benign pathologies. It avoids the morbidity and technical challenges required of radical cystectomy by avoiding the need for resection of adjacent structures and lymph node dissection. A subtrigonal technique has been described by Neulander [83] and a supratrigonal technique by Rowley [75].

32.6.3.3 Subtrigonal:

Neulander et al. [83]

The patient is positioned in low lithotomy with a Foley catheter in the bladder. Both extraperitoneal or intraperitoneal approaches can be taken.

A low midline incision is made. The ureters are isolated and transected as close as possible to the bladder. The bladder is then distended and the retropubic space developed. The bladder is mobilized from its lateral attachments. The visceral peritoneum on the bladder is incised laterally and extended anteriorly towards the retropubic space. The bladder is then filled and bivalved longitudinally in the anterior midline, from the level of bladder neck through the dome to the level of trigone posteriorly. The peritoneum on the posterior bladder wall is then incised horizontally at the level of the trigone.

In males, a plane is developed between the bladder and seminal vesicles, using the vas (which can be preserved) as a guide. The trigone is incised longitudinally in the midline to the

level of the bladder neck. The plane between the seminal vesicles and bladder are further developed. After the bladder is bivalved, the lateral flaps of the bladder wall and trigone are freed from the underlying seminal vesicles. The bladder neck is transected and lateral dissection and excision of the lateral bladder flaps are completed. Maintaining the dissection medial and anterior to the major branches of the vesicle pedicles minimizes bleeding. The terminal branches of the bladder vascular pedicles are managed with clips or energy devices.

32.6.3.4 Subtrigonal Cystectomy Outcomes

Neulander reported a series of 19 patients who underwent subtrigonal cystectomy between 1990 and 1999 [83]. Mean operative time was 30 minutes for the cystectomy portion and mean blood

loss was 300 ml. No complications directly attributable to the cystectomy was reported with 15 months follow up.

32.6.3.5 Supratrigonal:

Rowley et al. [75]

Rowley describes a similar approach to the bladder, as demonstrated in Fig. 32.8 [75]. With the supratrigonal technique, however, after the bladder is bivalved the lateral segments of the bivalved bladder are amputated with electrocautery, leaving behind the bladder base (trigone, and bladder neck). The remaining mucosa is then peeled off piecemeal and the plane between it and the underlying detrusor is cauterized. The remaining mucosa on bladder neck is fulgurated. The peritoneal flaps are reapproximated to cover the urethra.

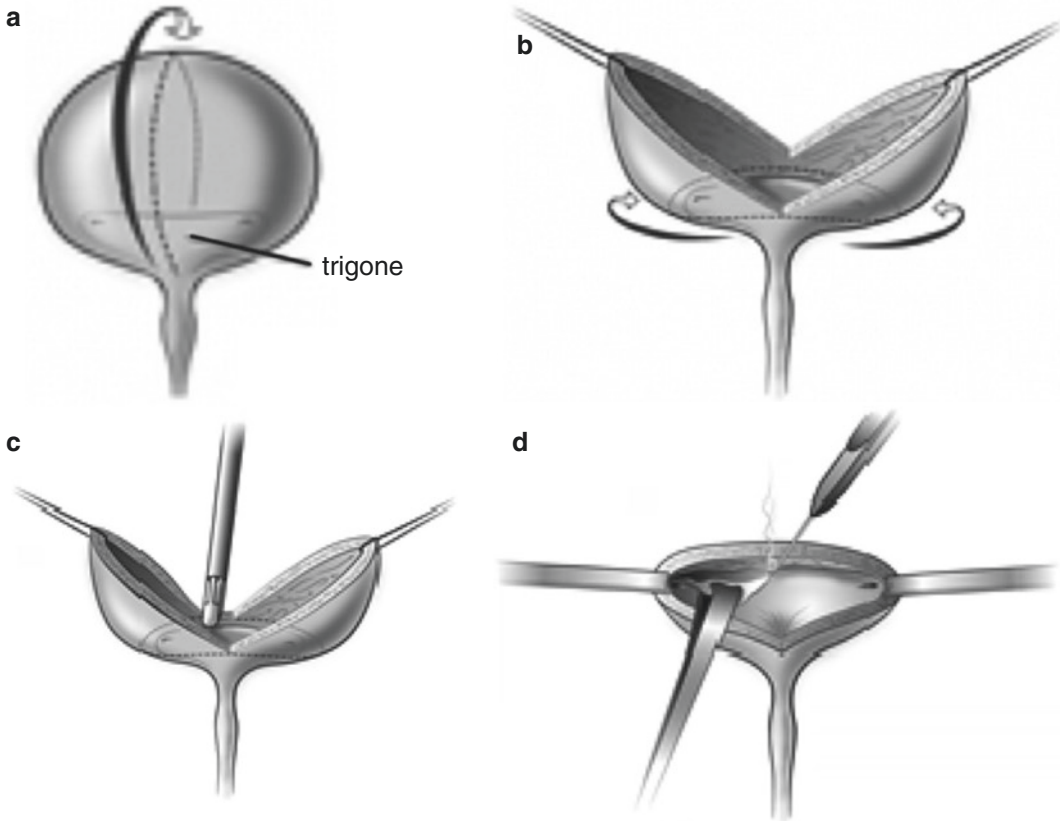


Fig. 32.8 Illustration of simple cystectomy [75]

32.6.3.6 Supratrigonal Cystectomy Outcomes

Rowley et al. reported outcomes in a series of 23 patients [75]. Mean operative time for cystectomy was 27.5 min with an average blood loss of 231.5 ml. No complications directly attributable to the cystectomy were reported.

32.7 Conclusion

Continent and incontinence diversion, with or without outlet closure or cystectomy, are the last resort for the male patient with unreconstructable urethral disease, the technique utilized should be tailored to the patient's disease process, risk factors, and goals of care. The significant morbidity associated with urinary diversion means it should only be pursued in carefully selected patients with consideration of their individual clinical need, risk factors, and goals of care. Pre-operative counseling is essential to ensure patients goals and expectations align with all possible outcomes.

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Robot-Assisted Reconstruction of the Lower Urinary Tract

33

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33.1 Introduction

Robotic-assisted approaches to posterior urethral stenosis build upon principles of traditional open and endoscopic management. These foundational modalities evolved from experiences with a diverse array of pathologies, each with unique anatomic considerations.

Understanding the role and limitations of these surgical techniques is a critical prelude to discussion of robot-assisted reconstruction. We briefly review the techniques historically utilized for lower urinary tract stricture disease separated by etiology, as the surgical management and approach to the posterior urethra and bladder neck may differ markedly [1, 2].

33.1.1 Radiation-induced Bulbomembranous Urethral Stenosis

Reported rates of urethral stricture following pelvic radiation therapy vary by modality, with a cumulative risk of 1.8–4% after brachytherapy (BT) alone, 1–2% following external beam radiotherapy (EBRT), 5.2–11% after combined EBRT+BT, and nearly 32% with high-dose BT [3, 4]. Clinically significant stenosis may manifest many years after the initial insult [5]. Depending on the proximity and dose of radiation delivered to the periapical urethra, the bladder neck may become more fibrotic and consequently less able to coapt or relax [6]. Poor vascularity of radiated tissues precludes appropriate healing, and radionecrosis of the prostate is common, hampering the reliability of anastomotic sutures [7]. Definitive repair is especially challenging when the stenosis spans the membranous urethra, due to difficulty in accessing this region. In the setting of prior radiation, the likelihood of recurrent stenosis after dilation or direct-vision internal urethrotomy (DVIU) approaches 50%, and repeated endoscopic manipulation may worsen fibrosis and delay definitive management [7, 8].

Consequently, consideration for early open surgical repair of bulbomembranous radiation-induced stenosis (RIS) has been advocated. The perineal approach, as described by Hofer et al., involves transection through the stricture, cir-

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cumferential mobilization of the distal urethra, and aggressive resection of all scarred or necrotic tissue from the proximal urethral stump [5]. If prostatic radionecrosis is encountered, removal of this diseased tissue with a rongeur is performed, including debridement of any involved periosteum of the pubic symphysis. Following clearance of all scar tissue, primary anastomosis is performed in a tension-free manner. Success rates have been reported as 70–85% at long-term follow-up [7]. De novo stress urinary incontinence (SUI) occurs in 33–43% of patients postoperatively, for which staged placement of an artificial urinary sphincter (AUS) is offered [9]. Recurrences were managed with endoscopic balloon dilation or transurethral incision. Critically, these outcomes are derived largely from cohorts of patients with strictures measuring 2 cm or shorter, most of whom had undergone multiple prior endoscopic interventions.

For longer RIS or those with more proximal involvement, adjunctive mobilization techniques including partial pubectomy, partial prostatectomy, or corporal rerouting may be employed. Chung et al. evaluated the incidence of SUI in cohorts of patients undergoing posterior urethroplasty for stricture induced either by radiation or pelvic fracture urethral injury (PFUI) [6]. Most patients with RIS who developed de novo SUI had prostatic urethral involvement (75%), whereas SUI after urethroplasty for PFUI was significantly less common (3%). Adjunctive mobilization measures were undertaken in a majority of RIS cases, whereas these techniques were uncommonly employed in the approach to PFUI. Altogether, these findings imply that the more proximal dissection risks damage to the external sphincter resulting in a greater likelihood of SUI, especially in patients with RIS where the bladder neck may already be damaged. Notably, longer RIS have been associated with greater rates of postoperative SUI, also possibly due to a need for more extensive urethral mobilization [5].

Longer or more proximal strictures may require additional strategies including an abdom-

inoperineal approach, or consideration of flap or graft urethroplasty. The open abdominoperineal anastomosis couples the perineal technique described above with mobilization of the bladder via a midline abdominal incision. An inferior pubectomy with removal of a 2–3 cm fragment is often required to expose the site of the anastomosis [7]. Buccal mucosal graft urethroplasty has been reported to carry a 71–83% success rate but should be accompanied by a vascularized graft bed such as a gracilis flap, because an irradiated bed may not have sufficient vascularity to support a graft [10, 11].

Surgical management of RIS may portend higher risk for complications of subsequent AUS placement. An analysis by McKibben et al. demonstrated that prior urethroplasty and history of pelvic radiation were independently associated with AUS cuff erosion [12]. These complications could result from impaired perfusion of an ischemic segment of urethra attributable to effects of radiation, devascularization from mobilization during urethroplasty or both [13]. Bulbar-artery sparing urethroplasty has been proposed as a method to obviate this potential complication [14], but may be difficult to undertake in the setting of RIS where natural tissue planes can be obliterated and excision of scar tissue is critical.

Despite refinements in open surgical technique, perineal or abdominoperineal approaches to RIS carry a cumulative risk of recurrence of 30% [5]. A significant proportion of patients experience de novo SUI postoperatively, especially with more proximal or longer RIS. Radiation is furthermore associated with an increased risk of AUS cuff erosion, leading to additional morbidity and need for subsequent reconstruction. Conceivably, these adverse outcomes arise due to the aggressive proximal urethral dissection required for adequate open excision of scar and exposure for anastomosis, possibly resulting in damage to the external sphincter and disruption to the bulbar arteries. Techniques involving less urethral mobilization could thus theoretically result in lower rates of de novo SUI or AUS cuff erosion.

33.1.2 Vesicourethral Anastomotic Stenosis

The risks of vesicourethral anastomotic stenosis (VUAS) following radical prostatectomy have been reported at 1–8%, presenting six months postoperatively [2]. In the era of robotic assisted laparoscopic prostatectomy (RALP) the risk has been reduced to less than 3%, presumably due to improved creation of a watertight vesicourethral anastomosis with appropriate mucosal eversion. Owing to the volume of prostatectomy performed worldwide it is likely that VUAS will remain an ongoing reconstructive dilemma [15]. While initial endoscopic management may be appropriate, 42% of patients ultimately require repeat intervention, with markedly reduced success rates for subsequent endoscopic procedures [16]. Specifically, dilation by itself performs poorly, with an overall recurrence-free rate of 13%, while transurethral cold knife incision, hot knife incision, and laser incision have recurrence rates of 25–55% [17]. The median time to recurrence was six months. Intralesional injections have been explored with mixed performance: mitomycin in particular has been associated with no significant change in recurrence rates [18].

Continence outcomes of endoscopic management are difficult to assess given varying degrees of post-prostatectomy incontinence prior to intervention, and lack of uniform reporting of long-term follow-up. Nevertheless, reports of transurethral incision for nonobliterative, short VUAS describe a rate of de novo SUI of 33–50% [19, 20]. Incision was more likely to fail where there was a concomitant history of pelvic radiation, and synchronous membranous urethral strictures were present in a majority of these patients. Staged placement of AUS was required for 92% of patients in a recent series [20].

Nearly one third of patients will have VUAS refractory to three or more attempts at transurethral management [16]. For such patients, or those with long (>2 cm) VUAS, open perineal, abdominal or abdominoperineal approaches

have been utilized. Analogous to patients with RIS, goals of these maneuvers include adequate excision of diseased tissue, exposure and mobilization of the distal urethral stump and bladder neck, and tension-free anastomosis. Multiple techniques have been proposed, including abdominoperineal excision, bladder neck reconstruction, and primary excision of the bladder neck with graft urethroplasty [2, 21]. In undertaking such procedures, the patient must be counseled on their extensive nature, length and potentially morbid nature, and the fact that incontinence is highly likely to occur or worsen postoperatively [22]. Risk of rectal, bladder and ureteral injury must be communicated. Prolonged operative time in exaggerated lithotomy position may additionally carry risks for neuropraxia [21]. Nikolavsky et al. report a contemporary series of open VUAS correction for patients with median stenosis length of 2.5 cm [23]. Inferior pubectomy was undertaken in eight of 12 patients due to the need for adequate exposure and visualization, with a mean operative time of 347 minutes and estimated blood loss of 400 cc. While 92% of patients had a patent bladder neck with long-term follow-up, half ultimately required intervention for de novo SUI.

The intraoperative difficulty, perioperative morbidity as well as postoperative incontinence following open repair of VUAS have been noted similarly by other investigators of comparable populations [24, 25]. Nevertheless, the putative advantage of avoiding perineal dissection in this population is that the bulbar urethra is preserved for future AUS if warranted. For long or recurrent VUAS, avoiding trans-sphincteric mobilization of the urethra may be desirable [26, 27]. Endoscopic approaches, while technically more facile, may carry a significant risk for recurrence and may impact continence although to a lesser degree than open correction. Technical advances in definitive repair for recurrent VUAS would ideally decrease operative time and perioperative risk while improving continence outcomes as feasible.

33.1.3 Bladder Neck Contracture

Owing to differences in etiology, epidemiology, length and relation to the external sphincter, bladder neck contracture (BNC) secondary to transurethral resection of prostate (TURP) or laser prostatectomy is discussed separately from VUAS [1]. The cumulative incidence of BNC post TURP is thought to be 1–12%. A single endoscopic intervention may result in a 58–73% durable recurrence-free rate [28]. However, patients who have recurrent BNC after multiple endoscopic interventions may be considered for the same gamut of open reconstructive procedures as with VUAS. In this patient population, open Y-V plasty reconstruction of the bladder neck, described first by Young in 1953 [29], has been described with varying results: the required bladder mobilization and tension on the anastomosis resulted in impaired vascularity and consequent anastomotic breakdown [30]. A modification of this technique, utilizing a T-shaped rather than Y-shaped bladder flap, has been proposed, with the aim of facilitating a tension-free anastomosis; preliminary patency and continence outcomes appear promising [31].

33.1.4 Advantages Offered by Robotic Approaches

The incremental modifications of open surgical techniques form the bedrock of the application of robotics in addressing RIS, PFUI, VUAS and BNC. Improved precision and expanded degrees of freedom while operating in the pelvis, for example, may obviate inferior pubectomy during correction of VUAS [32, 33]. Enhanced visualization may similarly decrease operative time and periprocedural bleeding, with potentially decreased length of hospital stay [34]. Importantly, these technical advances may result in further gains with respect to preservation of continence: by eliminating or reducing the need for trans-sphincteric or bulbar urethral mobilization, damage to the external sphincter or transection of the bulbar arteries may be avoided relative to open approaches to VUAS, RIS or BNC,

potentially allowing for improvement in postoperative SUI and reduction in AUS complications.

33.2 Evaluation and Surgical Indications

Indications for robotic posterior urethral and bladder neck reconstruction are identical to those for open abdominal or perineal repair. A robotic approach may be performed as means of primary repair, or after failed prior attempts at open or perineal reconstruction. Patients who have failed endoscopic management of vesicourethral anastomotic stricture or bladder neck contracture following transurethral procedures are candidates for robotic assisted laparoscopic reconstruction using a Y-V plasty approach. Individuals with PFUI or RIS may benefit from a robotic approach to posterior urethroplasty. Likewise, prostatic urethral stenosis can be managed with robotic assisted prostatectomy.

After a careful history and physical exam, cystourethroscopy is essential for evaluating the level of obstruction within the lower urinary tract. The authors prefer to use a flexible cystoscope for initial evaluation in the clinic setting; upon entering the proximal urethra, we ask the patient to tighten their rhabdosphincter to evaluate the level of obstruction relative to the external sphincter. The length and caliber of the obstructing segment are noted. Stenoses at the bladder neck, prostatic urethra and membranous urethra (at or above the external sphincter), are approached with robotic assistance for posterior urethral reconstruction. Bulbar urethral stricture disease distal to the membranous urethra is approached through a traditional perineal incision. Transsphincteric strictures or stenoses which span the urogenital diaphragm may benefit from a combined approach with robotic and perineal exposure (Fig. 33.1).

Patients with urinary retention should undergo suprapubic catheterization in advance of their definitive surgery, to allow for urethral rest for approximately four weeks and subsequent evaluation. Additional work-up may include retrograde urethrogram and voiding cystourethrogram, or sonourethrogram for those who have anterior

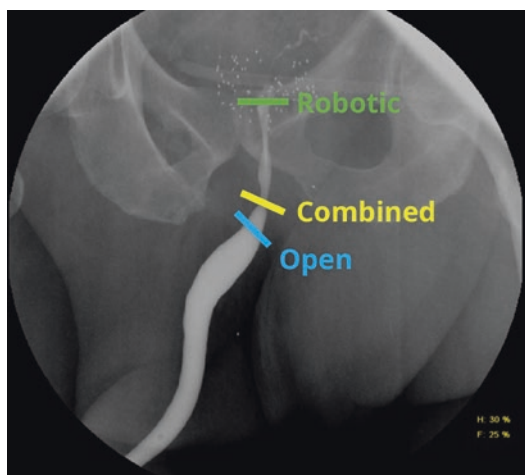


Fig. 33.1 Location of the stenosis or stricture relative to the external sphincter determines the surgical approach. Bladder neck contractures, vesicourethral anastomotic and prostatic urethral stenoses, proximal to the membranous urethra, are approached robotically. Transsphincteric stenoses and strictures may require a combined robotic abdominoperineal approach. Strictures distal to the membranous urethra are best managed with a traditional perineal approach

urethral stricture disease. Concomitant distal urethral strictures should be addressed prior to posterior urethroplasty.

If a patient's history raises suspicion for compromised bladder capacity or function, urodynamics may be useful in determining which individuals are poor candidates for a robotic approach. In patients with small capacity (100 ml or less), hypocontractile and acontractile bladders, we recommend chronic catheterization or urinary diversion rather than robotic reconstruction. Radiation cystitis that is refractory to hyperbaric oxygen therapy and intravesical therapy is another contraindication to reconstruction.

33.3 Preoperative Preparation

Preoperative urinalysis and culture must be obtained to allow for appropriate preoperative antimicrobial treatment. Mechanical bowel preparation is not necessary. Given the low likelihood of major bleeding, a type and screen are adequate for laparoscopic and robotic procedures.

33.4 Informed Consent

Preoperative counseling involves discussion of risks, benefits and alternatives, including intraoperative risks of urinary tract infection, bleeding requiring transfusion, injury to adjacent structures including the bladder, ureters, rectum, bowel and major vessels, as well as cardiovascular, pulmonary and thromboembolic complications; perioperative complications include incisional hernia, hematoma formation, breakdown of the urethral or bladder neck repair, persistent urine leak with potential fistula formation, recurrent stenosis, rectovesical or rectourethral fistula formation should a rectal injury occur. Patients should be counseled that surgical treatment of the stenosis may lead to post-operative urinary incontinence, necessitating artificial urinary sphincter placement to restore continence.

33.5 Setting Up the Operating Room

33.5.1 Operative Equipment

The da Vinci Robotic System (Intuitive Surgical, Sunnyvale, CA) Xi or SP (Single Port) systems are preferred for robotic posterior urethral reconstruction. While we have used the Si system for reconstruction, the Xi system allows for easy side dock for current perineal access. Compared to the Xi, the newer da Vinci SP system offers improved ability to work within a narrow space deep within the pelvis. An AirSeal filtered tube set and access port (ConMed, Utica, NY) allows for maintenance of pneumoperitoneum in cases of concurrent perineal dissection. A flexible cystoscope is used to localize the distal extent of the stricture, and to evaluate the location of the urethral rhabdosphincter.

33.5.2 Patient Positioning and Preparation

After induction of general anesthesia, an orogastric tube should be placed to decompress the

stomach. Patients are positioned in low lithotomy for access to the perineum and anus. Arms may be tucked to the sides with padding to avoid median and ulnar nerve injuries. Likewise, the knees, calves and any bony prominences should be padded carefully to prevent excess pressure and neuromuscular complications. The patient should be adequately secured to the table for steep Trendelenberg positioning.

Pneumatic compression stockings are routinely placed, in addition to administration of 5000 units of subcutaneous heparin for patients at moderate to high risk of venous thromboembolism.

Intravenous antibiotics are administered up to one hour prior to the start of the procedure, either with a cephalosporin for negative preoperative urinalysis or an antibiotic targeted to the patient's urine culture results (Wolf AUA guidelines stewardship).

It is important to maintain close communication between the anesthesiology and surgical teams intraoperatively to prevent or identify complications of carbon dioxide insufflation and pneumoperitoneum.

33.6 Surgical Technique

33.6.1 Vesicourethral Anastomotic Stenosis Following Radical Prostatectomy

Pneumoperitoneum is established using either a Veress needle or using an open Hasson technique. CO₂ insufflation pressure is typically maintained at 10–5 mm Hg throughout the operation. After initial placement of an 8 mm metal robotic trocar for the camera, our practice is to perform regional transverse abdominis plane (TAP) blocks under visualization. The blocks are administered through the triangle of Petit on each side, depositing local anesthetic in the plane between the internal oblique and transverse abdominis muscles to target the innervation of the anterolateral abdominal wall.

Additional 8 mm metal robotic trocars are placed under visualization in a configuration

similar to that of a robotic radical prostatectomy, shifted to either the left or right side to preserve the contralateral suprapubic tube tract through the prevesical space. If the patient does not have a suprapubic catheter, the port placement is no different. Preservation of the space of Retzius on one side may allow for greater ease of eventual inguinal artificial urinary sphincter reservoir placement through the inguinal canal, should the patient require this. An example port configuration is depicted in Fig. 33.2. Monopolar scissors, bipolar forceps, and prograsp forceps are the working arms of the surgeon, while the assistant utilizes a lateral 8 or 12 mm assistant port for passage of needles and the 5 mm AirSeal port for suctioning and retraction.

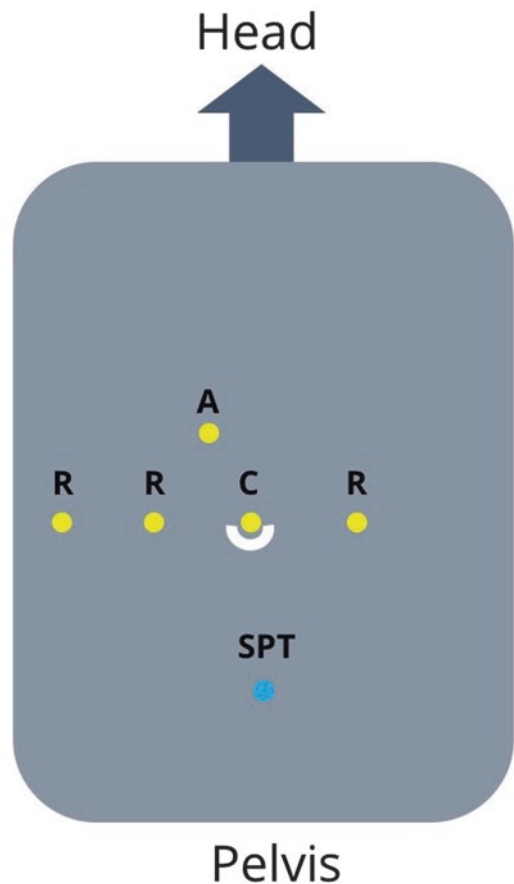


Fig. 33.2 Standard port placement for robotic urethral and bladder neck reconstruction is shifted to the right or left, away from a preexisting suprapubic tube if present. (Image illustrated by Zackary Herbst)

The robot is docked from the side to allow for concurrent perineal access. The degree of obstruction and location of the stenosis relative to the external sphincter is then assessed using flexible cystoscopy through the urethra, and if needed, antegrade via the suprapubic tract. If the urethra is not entirely obliterated, an anterior Y-V plasty technique is performed with a purely retro-pubic approach and preservation of the posterior plane (Fig. 33.3).

If the urethra is completely or nearly completely obliterated (5Fr or smaller), a circumferential urethral dissection is required. A posterior, retrovesical dissection is performed first to reduce the risk of rectal injury. The vasa deferentia and seminal vesicles are completely dissected behind the bladder, and Denonvillier's fascia opened to separate the posterior urethra from the rectum using careful sharp dissection and minimal bipo-

lar electrocautery. The proper surgical plane is relatively avascular. An EEA sizer can facilitate identification of the rectum during the posterior dissection. The urogenital diaphragm is exposed.

Using Firefly™ technology with either anterior or posterior approaches, the light of the transurethral cystoscope is used to precisely identify the distal extent of the stricture (Fig. 33.4). The urethra is then incised or transected with Firefly™ and cystoscopic guidance (Figs. 33.5 and 33.6). The scar tissue is excised using electrocautery and sharp dissection, leaving healthy bladder neck tissue behind. Determination as to whether to perform excision and primary anastomotic (EPA) repair versus Y-V advancement approach depends on how visible and accessible the proximal opening is based on pelvic anatomy and adiposity. If a posterior approach to anastomosis is not feasible, an anterior dissection is then

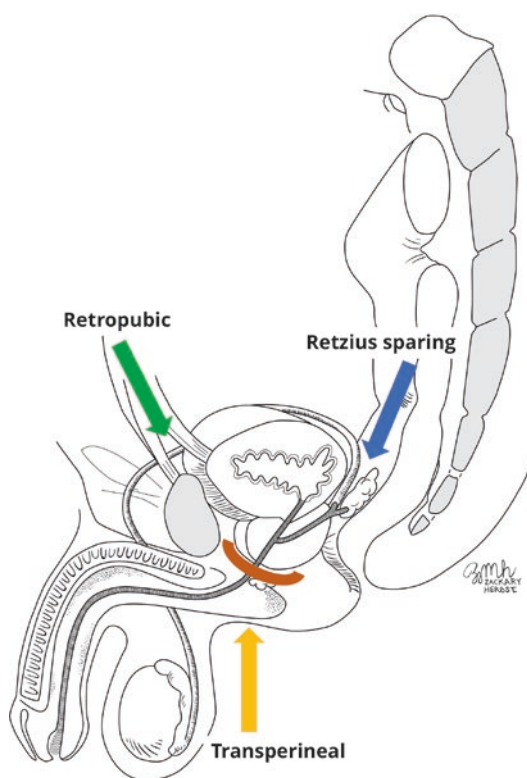


Fig. 33.3 Intraoperative approaches may be anterior (retropubic), posterior (Retzius sparing), transperineal, or a combination based on the location and degree of stenosis present

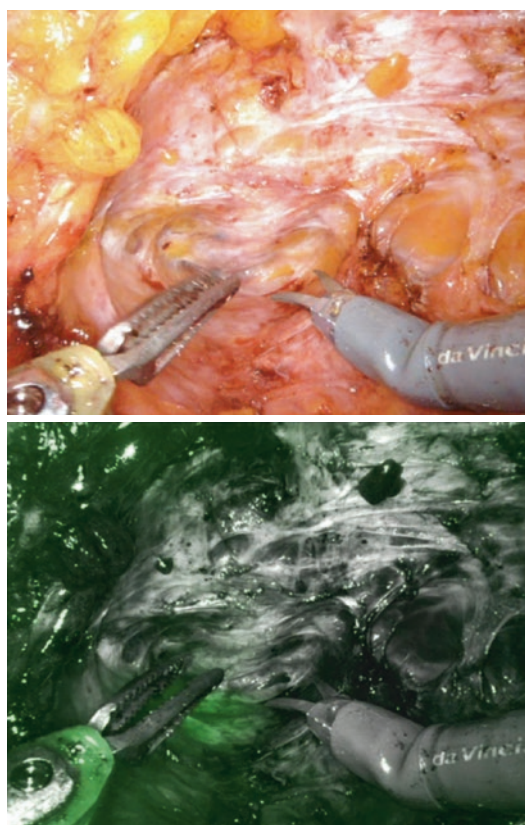


Fig. 33.4 Retropubic dissection with white light (above), Firefly™ (below)

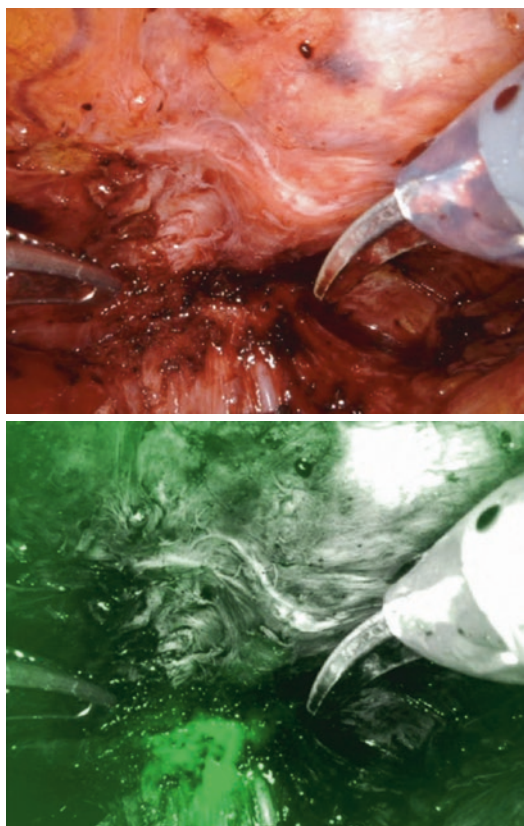


Fig. 33.5 Incision of urethral stenosis with white light (above), Firefly™ (below)

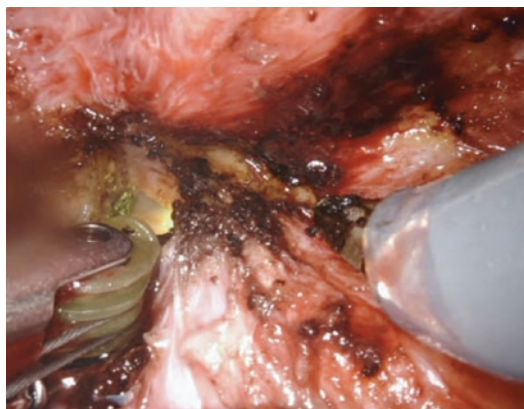


Fig. 33.6 Incision of urethral stenosis under cystoscopic guidance

performed. The peritoneum is incised medial to the obliterated umbilical ligaments bilaterally and the urachus is divided. The bladder is then “dropped” posteriorly allowing for entry into the

space of Retzius. The cystoscope is then used with Firefly™ assistance to identify the distal extend of the stricture, and the urethra mobilized circumferentially to this point before being transected, joining with the posterior urethrotomy. If the anastomosis cannot be performed even after complete anterior and posterior mobilization, a perineal incision is made to mobilize the urethra distally and provide additional urethral length.

Holding sutures are placed on the bladder neck as well as the membranous urethra to assist with retraction. The authors prefer a 3–0 barbed V-loc™ (Covidien, New Haven, CT) suture for the anastomosis. The urethra is calibrated with a catheter to at least 22 French. The anastomosis is performed by bringing the anterior aspect of the bladder neck to the urethra using a double-armed barbed suture. After placement of the catheter, the posterior aspect is closed in a running fashion using the barbed suture. Using the cystoscope, the anastomosis is visualized intermittently to confirm satisfactory mucosal coaptation and patency of the repair.

If there is excess tension on the anastomosis, the distal urethra may be mobilized through a perineal approach. A perineal incision is made and the corpus spongiosum exposed, dissected proximally and distally until a tension-free anastomosis can be achieved.

After tightening of the anastomotic sutures, the final catheter is placed and the bladder filled to 180 mL to confirm a watertight closure.

If feasible, use of an omental flap is preferred for coverage between the pubis and anastomotic suture line. A gracilis flap or rectus flap may be harvested and delivered into the abdomen for robotic access. Intravenous indocyanine green (25 mg/10 mL) can be administered in 1 mL aliquots to identify vascular pedicles under Firefly™ visualization. For anterior approaches, the muscle flap may be sutured in place between the urethral suture line and pubis; for anterior and posterior dissections, the flap may be split partially lengthwise and wrapped around the repair anteriorly and posteriorly.

The peritoneum is then partially closed over the repair in preparation for pressure regulating balloon placement if AUS is eventually needed.

An opening is left in the peritoneal closure for the pedicled flap. A closed system suction drain (Jackson-Pratt) is then placed in the dependent portion of the flap, over the closure.

The trocars are then removed under direct visualization and port sites closed. If trocars larger than 8 mm are used, we close the fascia prior to deep dermal and subcuticular closure.

33.7 Management of Bladder Neck Contracture following Transurethral Procedures

In cases of bladder neck contracture following transurethral resection of the prostate, with the prostate in situ, surgical management begins with similar initial exposure. An anterior or posterior approach is taken based on the degree of bladder neck stenosis, as described above. Placement of temporary open-ended ureteral stents may be required pending proximity to the trigone. Partial or total prostatectomy is performed for excision of the stenotic segment. The anastomosis is performed in a similar manner with use of a cystoscope or 22 French catheter for calibration and exposure of the distal lumen. A suprapubic tube may be placed depending on the surgeon's confidence in the anastomosis.

33.8 Posterior Urethroplasty for Radiation Stenosis and Pelvic Fracture Associated Urethral Distraction Defect

For patients with radiation-associated posterior urethral stenosis or pelvic fracture associated urethral distraction defect, the goal of a robotic approach is maximizing exposure while minimizing risk of incontinence. As a result, we tend to leave the prevesical space intact, performing the repair through a posterior approach as described above. Under cystoscopic guidance with Firefly™, the external urinary sphincter can be identified and avoided. The anastomosis is then performed with a similar technique as

described above, performing concurrent perineal dissection if additional length is required.

33.9 Postoperative Management

Patients are admitted for 23-hour post-operative observation and are typically ready for discharge on post-operative day one. The creatinine level from the JP drain output is checked to ensure the absence of urine leak prior to removal. Patients are discharged with the Foley catheter to gravity. A voiding cystourethrogram is performed in clinic two weeks later at the time of catheter removal. If a suprapubic tube is present, the patient may be allowed to void per urethra with a suprapubic tube capping trial to ensure low post-void residuals.

33.10 Functional Outcomes

Robotic-assisted lower urinary tract reconstruction has shown great promise in early series with regards to achieving durable patency while preserving continence.

33.10.1 Patency

Patency rates range from 75% to 100% in the three studies to date on robot-assisted Y-V plasty for VUAS and recalcitrant BNC [32, 34, 35]. Success rates of standard abdomino-perineal and transperineal approaches are comparable at 87–100% in the absence of radiation therapy; however nearly all patients managed with this open approach have post-operative incontinence [36–38]. Of the 12 patients included in the multi-institutional Trauma and Urologic Reconstructive Network Surgeons (TURNs) series, three (25%) had recurrent strictures of <17Fr identified on post-operative cystoscopy, and two responded successfully to direct vision internal urethrotomy with improvement in voiding symptoms and no further intervention. The third had a stable 14Fr bladder neck contracture at six months and underwent AUS placement. Musch and col-

leagues recurrent BNC in two of 12 patients, both of which were observed at a median 23.2 months' follow-up.

33.10.2 Incontinence

Granieri and colleagues reported two of seven (29%) patients with persistent incontinence of one pad per day at a median follow-up of eight months [35]. In their cohort of 12 patients with a median follow-up of 23 months, Musch et al. report one case of de novo stress urinary incontinence that resolved spontaneously. The TURNS group reported an incontinence rate of 18% among 12 patients, with incontinence defined as more than one pad per day or requiring additional incontinence procedures [34]. In comparison, incontinence rates with an open approach have been reported at 73% [23].

33.11 Complications

Complications of robotic lower urinary tract surgery mirror those of other robotic pelvic operations. These include complications of positioning, initial access, bleeding, visceral injury, ureteral injury, equipment malfunction, need for open conversion, venous thromboembolism, and anastomotic leak.

Of the 31 patients across three series reported to have undergone robotic bladder neck surgery, one significant complication was reported [32, 34, 35]. This patient developed rhabdomyolysis, peroneal neuropathy and a pubovesical fistula requiring pubic bone debridement, repair of pubovesical fistula and rectus flap, with an initial operative time of 390 minutes. The patient ultimately required repeat Y-V plasty of BNC with total pubectomy [35]. Extended operative time is an established risk factor for positioning-related complications. Lower extremity neuropathy in robotic assisted laparoscopic prostatectomy (RALP) has been reported at 1.3%, with a mean operative time of 496 min-

utes in patients who developed neuropathy versus 366 minute in those without [39]. Mean operative time was reported at 240 minutes by Granieri and colleagues, and median operative time in the TURNS and Kroepfl groups 216 and 178 minutes, respectively.

Across the three series, mean blood loss was 67 ml to 100 ml with no transfusions required [32, 34, 35]. There were no instances of open conversion, anastomotic leak, transfusion, or equipment malfunction among published series, though overall number of patients and follow-up time is currently limited. Given similarities in patient positioning (lithotomy with Trendelenburg), operative time, and surgical field, certain complications can be gleaned from early RALP literature. The rectal injury rates in two large series of RALP was 0.17% for non-irradiated pelvises [40], and 0.9% in salvage RALP [41]. Rectal injury for robotic repair of VUAS, recalcitrant BNC and RIS has yet to be reported, however will likely vary based on anterior versus posterior approach and pre-operative radiation history. Until larger series are published, surrogate measures from salvage RALP may be used to counsel patients on potential complications.

33.12 Conclusions

Repair of posterior urethral stenoses, bladder neck contractures and vesicourethral anastomotic stenoses remain a challenge even for expert reconstructive urologists. Incorporation of emerging robotic assisted technology allows for improved visualization and precision suturing in areas that are difficult to expose using traditional open abdominal and perineal approaches. Long-term outcomes specific to robotic techniques are limited. However, robotic approaches show promise for maintaining the prevesical space and sphincter mechanism for early return to continence, and in periurethral tissue preservation for those who require future artificial urinary sphincter placement.

Key Summary Points

- For reconstruction of the posterior urethra and bladder outlet (for conditions such as radiation induced stricture, pelvic fracture urethral injury, vesicourethral anastomotic stenosis and bladder neck contracture), a robotic-assisted transabdominal approach may allow for enhanced visualization and improved dexterity in the deep pelvis.
- By avoiding extensive urethral mobilization, trans-sphincteric dissection, and bulbar artery transection, robotic assisted urethral and bladder outlet reconstruction has potential to preserve tissue integrity for continence preservation or future artificial urinary sphincter placement.
- Indications for robotic posterior urethral and bladder neck reconstruction are identical to those for open abdominal or perineal repair. A robotic approach may be performed as means of primary repair, or after failed prior attempts at open or perineal reconstruction.
- Preoperative cystourethroscopy helps to determine surgical approach: Stenoses at or above the external sphincter are approached with robotic assistance for posterior urethral reconstruction. Bulbar urethral stricture disease distal to the membranous urethra is approached through a traditional perineal incision. Transsphincteric strictures or stenoses which span the urogenital diaphragm may benefit from a combined approach with robotic and perineal exposure.
- Intraoperative concurrent cystourethroscopy allows for identification of the strictured segment during transabdominal robotic dissection and repair.
- Principles of intraoperative techniques include creation of a tension-free anastomosis, and bringing healthy vascularized tissue (such as an omental, gracilis or rectus flap) as needed into the area of repair.

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Impact of Urethral Reconstruction on Sexual Function

34

Enzo Palminteri, Nicolaas Lumen, Mirko Preto,
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34.1 Introduction

Established beliefs concerning outcomes in anterior urethral reconstruction are changing, with regard both to the impact on sexual activity and genital cosmetic appearance [1]. Following repair of anterior urethral strictures, successful outcome is generally defined as normal voiding without further invasive procedures. However, the urethra is also involved in sexual and genital functions and most patients undergoing urethroplasty worry about the impact of surgery on sexual life. Therefore, the aim of stricture repair is not only to restore urinary function but also to safeguard sexual activity and guarantee genital cosmesis.

A complete evaluation of anterior urethroplasty should include the sexual point of view, which seems to play an important role in overall postoperative patient satisfaction. Despite the importance of the sexual outcome following penile or bulbar urethroplasty techniques, very few studies have focused on these aspects so far. The most commonly reported sexual problems following anterior urethroplasty include: erectile and ejaculatory dysfunctions, penile curvature or

shortening, dissatisfactions with genital cosmetic appearance, sensorial impairment of genitalia and overall dissatisfaction about sexual life. The prevalence of specific postoperative sexual problems may be related to the site of urethral reconstruction (penile or bulbar) and to the technique of urethroplasty employed (graft versus flap and transecting versus non-transecting techniques). In penile urethral reconstruction, the increasing use of buccal mucosa seems to provide better results than the use of skin flaps which easily distorts the cosmesis and elasticity of the penis, thus increasing the risk of complications [1]. In bulbar reconstructions, graft augmentation techniques seem to have less impact on sexual outcome than transecting anastomotic techniques, which has been considered the gold standard for a long time.

Aim of this chapter is to analyse various anterior urethroplasty techniques for penile and bulbar reconstructions and related postoperative sexual complaints, providing also some technical hints on the surgical procedures in order to improve sexual outcomes.

34.1.1 Neuroanatomy

The understanding of the neuroanatomy of the urethra is a prerequisite for prevention or reduction of the neural injuries during the surgical urethral repairs. Two sets of nerves control erec-

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tile function. They are designated as autonomic (motor) and somatic (sensory) innervation.

The *autonomic system* consists of sympathetic (T10-L2) and para-sympathetic fibers (known as pelvic nerves: S2-S4) that make the pelvic plexus (Fig. 34.1). This latter is a 4–5 cm network lying on the posterolateral aspect of the bladder and the prostate. Its caudal fibers form the Cavernous nerves (also named “nervi Erigentes”) which travel posterolateral to the seminal vesicles towards the apex of the prostate. They then

accompany laterally the membranous urethra, located at the 3 and 9 o’clock positions external to the striated muscles [2, 3]. Finally they ascend superolaterally in the proximal bulbar urethra; at the penile hilum, the cavernous nerves pierce the corpora cavernosa to innervate the helicine arteries and the erectile tissue: therefore they are located superolaterally (at the 2 and 10 o’clock positions) to the proximal bulbar urethra (Fig. 34.2) [2, 3]. Detailed anatomic studies on the prostatic apex and membranous urethra

Fig. 34.1 Relationship of the nerves to the urethra

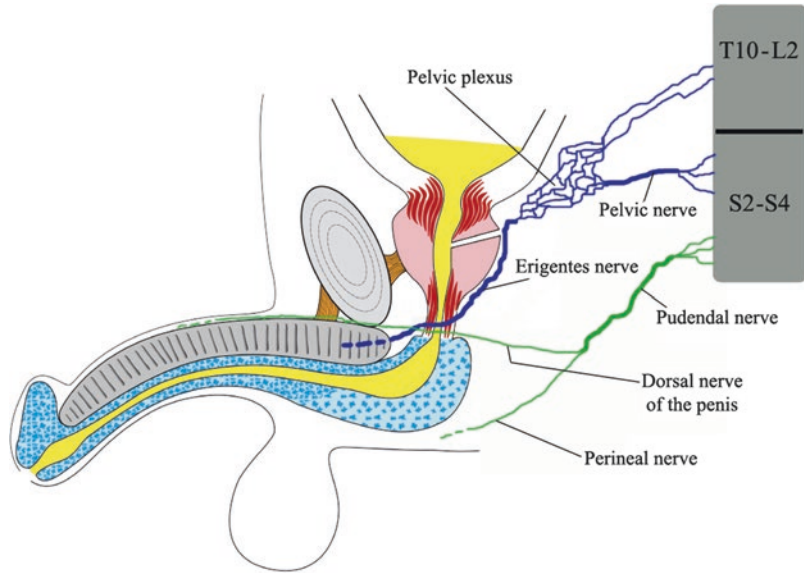
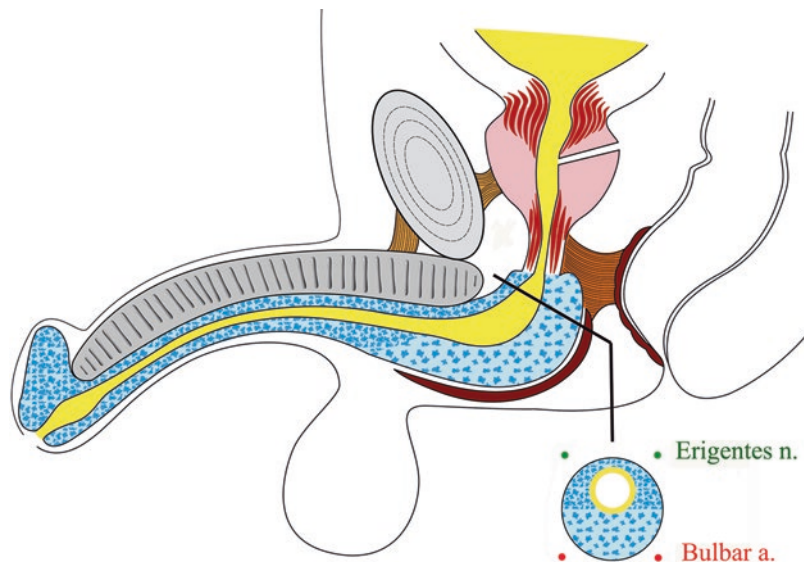


Fig. 34.2 The proximal bulbar corpus spongiosum reaches its greatest thickness in the “bulb” and then it disappears in the membranous urethra: in this area there are the two bulbar arteries (at 5 and 7 o’clock) and the two erigentes nerves (at 11 and 1 o’clock)



(relating to radical prostatectomy) have focused the location and importance of the neurovascular bundles, stressing the risk of damage to the erectile function due to urethral repair in the dorsal area of the proximal bulbar tract [3–5]. Hinata et al. described, based on new anatomical findings, a U-shaped mesh of cavernous nerves around the membranous urethra at the level of the rhabdosphincter which fuses at the dorsal side at the level of the penile hilum (Hinata et al.). The presence of cavernous nerve fibers at the dorsal side in the intercrustral septum was confirmed by the findings of Blakely et al. These new findings indicate that the cavernous nerves are a complex network with a more extensive location as previously assumed. [6, 7].

The *somatic system* consists of the paired pudendal nerves which receive contributions from S2-S4 and innervate the pelvis and anal perineum. They accompany the internal pudendal vessels through Alcock's canal to innervate the striated muscle of the pelvic floor (levator ani) and the penis (ischiocavernosus and bulbocavernosus muscles). The pudendal nerves also supply sensory perception to the pelvis and the perineum and terminate as the dorsal nerve of the penis.

The dorsal nerve of the penis is an important branch of the pudendal nerve: it travels underneath the levator ani and continues distally along the dorsolateral surface of the penis lateral to the dorsal artery, gives multiple branches, and terminates in the glans penis. Anterior urethral innervation is by the urethrobulbar nerve, a branch of the perineal nerve: this latter is a branch of the pudendal nerve.

34.1.2 Anatomical and Surgical Considerations

The bulbar urethra is emptied, following micturition, by its closure mechanism created by the elasticity of the spongy tissue, combined with the voluntary contraction of the bulbospongiosus muscle; in a similar way, an efficient urethral emptying, during ejaculation, is achieved by the combination of the bulbo-penile urethral closure-pressure with the intermittent reflex contractions of the spon-

gious muscle. In particular, erection of the spongy tissue not only considerably increases the passive urethral closure-pressure but it also increases the bulk of the bulb which, in turn, increases the effect of the reflex ejaculatory contractions of the surrounding bulbo-spongiosus muscle. Thus, organic emission is a function of the posterior urethra resulting from a simultaneous contraction of the bladder neck, sustained contraction of the seminal vesicles and opening of the distal sphincter. Once the emission has passed the distal sphincter, the continuous flow of the semen is converted into a forceful intermittent ejaculation by the anterior bulbo-penile urethral structure.

The bulbospongiosus muscles, together with the perineal central tendon, on which they pivot, contribute to the ejaculatory and urinary emission; for this reason, during urethroplasty, it is advisable to attempt to spare the central tendon and to reconstruct the muscles (Figs. 34.3 and 34.4) [8]. Yucel and Baskin supposed that the hypothetical surgical damage to the branches of the perineal nerves, during bulbar urethroplasty, may be responsible for the loss of rhythmic bulbar urethral contractions, causing difficulty in expelling semen (decreased force of semen emission, ejaculation only by manual compression of the perineum at the level of the urethral bulb) and urine [9]. They hypothesised that these sexual complaints could be caused by extensive dissection of the bulbo-spongiosus muscles, or by sectioning the central tendon, or by the neural damage to the perineal nerves during preparation of the bulbar urethra. Therefore it is worthwhile stressing the importance of preserving the central tendon, and of gently handling the bulbospongiosus muscles and reconstructing them at the end of any bulbar urethroplasty.

With the aim to reduce semen sequestration Barbagli described a new muscle- and nerve-sparing bulbar avoiding dissection of the bulbospongiosus muscle from the corpus spongiosum and leaving the central tendon of the perineum intact [10].

However, it must be said that urethral reconstructive procedures inevitably impair the natural emptying mechanism of the spongy tissue, since they interrupt the structural muscle-elastic

Fig. 34.3 Externally the bulbar corpus spongiosum is enveloped in the bulbospongiosus muscle. The proximal bulbar urethra is anchored deep in the perineum, especially in the midline posteriorly by a fibrous septum: the perineal central tendon

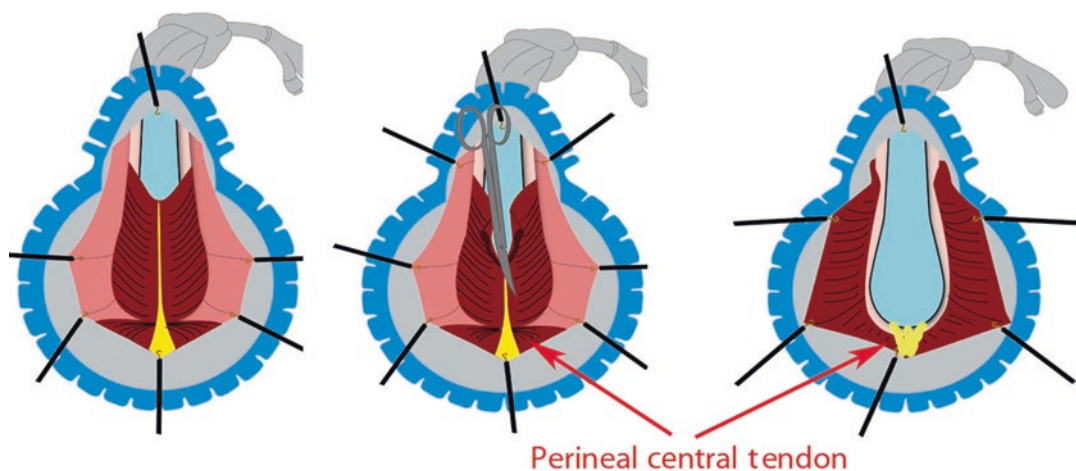
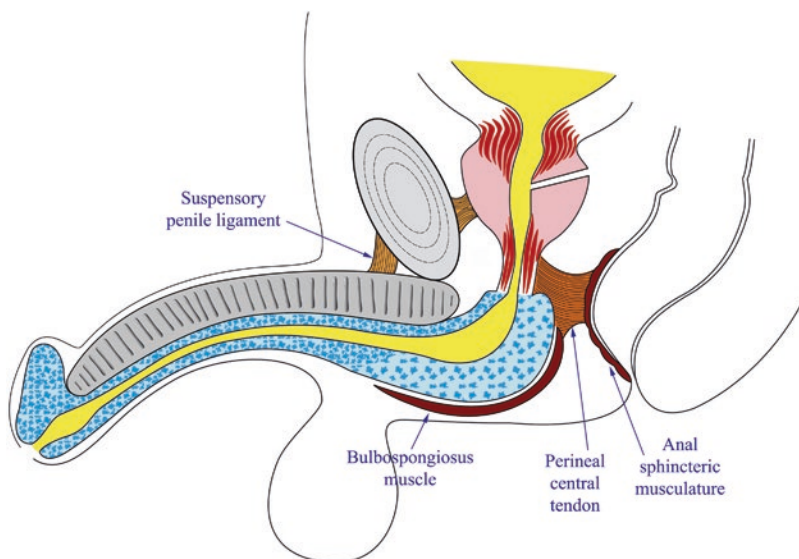


Fig. 34.4 During urethroplasty and opening of the bulbospongiosus muscle, it is advisable to spare the Perineal Central Tendon

circularity of the urethral tube which may stop the rhythmic urethral voiding contractions. Furthermore, urethral elasticity is often already impaired, to some extent, by the spongio-fibrotic disease [11].

34.2 Sexual Complaints Following Bulbar Urethroplasty

Bulbar strictures are repaired by means of anastomotic urethroplasties (AU) or by patch graft urethroplasties using Buccal Mucosa (BM) as

the graft of choice. Short strictures are traditionally treated by excision and primary anastomotic (EPA) urethroplasty. However, the shortening of the urethra and the vascular injury following urethral transection may lead to increased risk of complications, explaining why in some studies the AUs showed higher incidence of sexual problems such as penile curvature or shortening, impaired erection, decreased penile sensitivity and impaired sexual life, when compared with graft techniques (Table 34.1) [11–18]. Mundy showed that in patients who underwent anastomotic and patch graft urethroplasty the post-

Table 34.1 Sexual complaints reported following bulbar urethroplasty [9–15]

	Anastomotic procedures (%)	BM graft (%)
Penile curvature	36	8
Penile shortening	38	11
Impaired erection	79	15
Complete loss of erection	9	0
Overall dissatisfaction in erection	26	19
Temporary impotence	53	33
Impaired sexual life	57	19
Overall satisfaction regarding sexual life	74	97

operative impotence was temporary in 53% and 33%, and permanent in 5% and 0.9%, respectively [14]. Al-Qudah and Santucci, directly comparing AUs versus BM graft techniques in bulbar repairs, showed a higher incidence of sexual complications (chordee and ED) following AUs [15]. In his series of 153 men undergone EPA urethroplasty, Barbagli reported 23.3% of patients with postoperative ejaculation difficulty and 31.6% with neurovascular disorders (decreased sensitivity) of the glans or penis [16]; he hypothesized that these sensory disorders are related to vascular impairment of the spongiosum distally to the urethral section. In his experience with EPA urethroplasty, Morey reported 18% of complete loss of erection, 44% of chordee, 22% of decreased penile length, 45% of overall dissatisfaction in erection, 33% of erectile worsening noted by partner [12]. Kessler et al. noticed 36% of penile curvature, 38% of penile shortening, 79% of erection deterioration, 57% of impaired sexual life in patient undergone anastomotic techniques [17]. Beysens et al. reported a temporary decline in erectile and ejaculatory function after EPA but not after graft urethroplasty for bulbar strictures [18]. No prospective randomized trials comparing EPA with patch urethroplasty evaluating sexual function are to date available. Therefore, the level of evidence on this issue is low.

Following the urethral and spongiosal transection, the stricture is often longer than described at urethrography. Therefore to reduce the risk

of penile chordee, graft augmented anastomotic procedures have been advocated [16], but even with these techniques the problem of vascular damage after complete spongiosal transection is still present.

Recently, with the aim to minimize the surgical trauma and its potential complications, Jordan et al. first described a vessel- and spongiosum-sparing excision and anastomosis for proximal bulbar strictures [19]. Subsequently Andrich and Mundy proposed a new muco-mucosa anastomotic technique without transecting the corpus spongiosum [21].

For short bulbar strictures, EPA has been proposed as standard of care seen a composite 93.8% success rate with stable result on the long term [22]. However, with regard to sexual complications after transecting urethroplasty the literature is controversial (see above). In this context, it would be interesting to establish whether graft techniques could represent a valid alternative also for short non-obliterative bulbar strictures, traditionally treated by anastomotic procedures: this debate is currently ongoing. Therefore, with regard to bulbar reconstruction the next question to answer will be: “to transect or not to transect the urethra?”

Long bulbar strictures are usually treated by patch BM graft urethroplasty. The approach (dorsal vs ventral) to the bulbar urethral lumen and the location of the patch (dorsal vs ventral) has become contentious issues without winners [23]. Dorsal graft augmentation by the *Dorsal urethral approach* (Barbagli’s technique) has represented a revolution in urethral surgery and it has registered a worldwide diffusion because it offers the advantage of the graft being splayed, fixed and supported by the corpora [24]. Nevertheless, the disadvantage of this technique is the more extensive dissection and mobilisation of the urethra; furthermore, over time, Barbagli warned that the dorsal access might damage the erectile function and the bulbar arteries when dissection from the corpora needs to be very proximal [25, 26]. Therefore, he recommended his approach only for selected medium or distal bulbar strictures, whilst for the repair of proximal bulbar strictures the ventral approach would seem more advisable [27]. However, to date, no

data are available with regard to the hypothetical sexual complications related to the dorsal urethral approach. With the aim to reduce this surgical invasiveness, Kulkarni proposed a modified dorso-lateral approach avoiding the circumferential mobilization of the urethra and preserving its contralateral side [28]. This approach is useful particularly for long strictures, but in our experience some patients complained penile chordee: anyway, this complication is probably due to the length of the reconstruction rather than to the type of the technique.

The *Ventral urethral approach* is easier, less aggressive and more versatile than dorsal approach. It is easier because it provides a direct access to the urethral lumen and a clear visualisation of the stricture; this easiness of accessibility is important, especially in the proximal bulbar tract. It is considered less aggressive because there is a minimal dissection without a wide and circumferential mobilization of the urethra, thus reducing, in proximal bulbar strictures, the risk of erectile dysfunctions that has been feared when using the dorsal access. Ventral approach is versatile because, depending on the quality of the urethral plate, it allows surgeon to choose *in situ* among different solutions: one-side dorsal grafting (Asopa's technique) or one-side ventral grafting or two-sided double dorsal-ventral grafting or transecting and graft-augmented anastomosis or perineostomy [29–32].

Ventral grafting using the ventral approach is worldwide performed [23, 31]. Some surgeons complain about the risk of graft-weakening with urethral sacculation or fistula. Nevertheless, the abundant ventral spongiosum guarantees a satisfying coverage and support for the graft, and the literature fails to show what above supposed. This was probably a problem in the past, when some surgeons did not cover the graft with the spongiosum (spongioplasty). We studied the impact of ventral grafting on sexual life showing that 20% of the patients reported post-voiding dribbling, which might be due to a slight weakening of the grafted urethral floor (Fig. 34.5) [33]. However, except this minimal complication, it is important to highlight that no patients reported sexual complaints and all reported an improvement in sexual life [33].

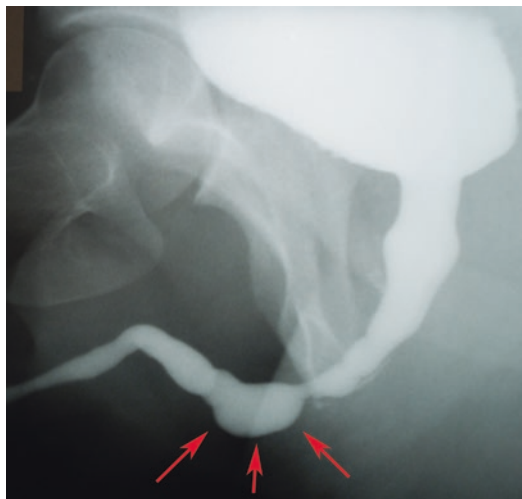


Fig. 34.5 Weakening of the urethral floor after ventral graft urethroplasty

In the case of a very narrow urethral plate, it is possible to transect and excise a portion of the urethra and perform a graft-augmented anastomosis [20, 34]. On the other hand, in these cases the two-sided dorsal plus ventral double grafting (DVDG) (Fig. 34.6) represents a valid alternative to the aggressive anastomotic procedures since, by avoiding the transection of the spongiosum, it preserves the urethral plate [32]. The aim of double grafting was to maintain the integrity of the urethral vascularisation and the urethral length, thus reducing the sexual complications related to the anastomotic techniques as mentioned above. Furthermore, reducing the width of a single ventral graft, the double graft technique may decrease the risk of diverticula with post ejaculation dribbling and semen sequestration. We compared our DVDG sexual results to those previously reported using the same erectile function questionnaire (Coursey's questionnaire) after transecting anastomotic techniques [12, 35]. In our DVDG series, none of the patients reported postoperative erectile problems or dissatisfaction regarding sexual life; conversely, erectile improvement was noted by the partner in 19%, whereas 7% reported an increase in the frequency of intercourse probably secondary to the effect of the successful urethral disease management on the

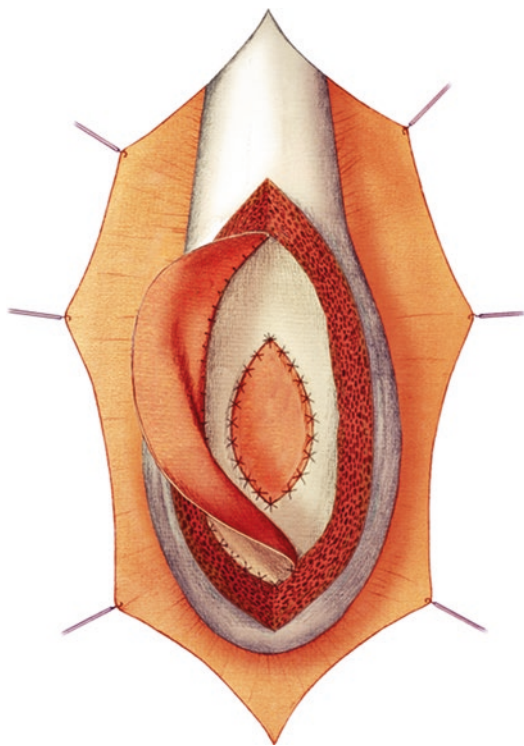


Fig. 34.6 Two-sided dorsal plus ventral double grafting

patients QoL [35]. Currently, the lack of validated and adapted questionnaires to study men undergoing urethral surgery hinders an appropriate evaluation of sexual dysfunctions after urethroplasty.

34.3 Sexual Complaints following penile Urethroplasty

As far as concerns penile urethroplasty, recent changes have been introduced to improve urinary, sexual and cosmetic outcomes. These changes include the increasing use of buccal mucosa grafts and of dorsal urethral augmentation by means of the Asopa [30] or Barbagli [24] or Bracka [36] technique. Penile urethroplasty can be performed in either a one-stage (Asopa or Barbagli technique) or two-stage procedure (Bracka technique), the choice being based on the etiology of the stricture and on the local conditions of the urethral and penile tissues [37].

In a normal penis (i.e., ischemic strictures) with penile skin, *dartos fascia*, *corpus spongiosum* and urethral plate available for urethral reconstruction, a one-stage urethroplasty is the technique of choice worldwide. Conversely, in an abnormal penis (i.e., failed hypospadias repair or *Lichen Sclerosus*) where normal penile skin, *dartos* and urethral plate are not available for urethral reconstruction, a staged urethroplasty is generally recommended [36–39].

The choice of the surgical technique must also be based on the exact anatomic characteristics of the local tissue in order to ensure flap or graft take and survival. Furthermore, sexual function can be placed at risk by any type of surgery of the genitalia, and dissection must avoid interference with the neurovascular supply to the penis. The use of flaps or grafts should not compromise penile length, and certainly should not affect the penile appearance. Today, the use of the penile flaps is less frequent since it requires an appropriate and difficult training. When compared to the graft techniques, surgery with flaps is more difficult, has higher operative time, lower level of patient satisfaction and higher percentage of complications [1]. Indeed, using flaps easily distorts the cosmesis as well as the elasticity of the penis. Furthermore, flaps increase the risk of complications impacting upon sexual life: hairs in the urethra (if scrotal flaps), urethral weakening with diverticula (causing semen sequestration), fistulas, wide foreskin necrosis, chordee and penile rotation [40–43]. The advent of buccal mucosa as a substitute material has led to an improvement in the functional and cosmetic results (allowing a more accurate and original-appearing reconstruction of the glans meatus) and has improved the sexual outcome. Conversely, anastomotic procedures are contraindicated in the pendulous urethra because shortening, during erection, would easily result in chordee also impairing sexual life. However, when compared to bulbar urethroplastic procedures, penile urethroplastic procedures are unlikely to be associated with erectile dysfunctions as there is no involvement and damage to the cavernous nerves and/or arteries. On the other hand, the altered appearance of the penis, sometimes observed following difficult recon-

structions, may be the cause of dysmorphophobia and psychogenic erectile dysfunction.

34.4 Conclusion

Anterior urethra stricture repair should guarantee the best urinary and sexual outcomes. When possible, the recommended technique should offer a wide enlargement of the urethral lumen by preserving the urethral plate, urethral blood supply and length.

Successful outcome, in anterior urethral repair, should be assessed not only by objective voiding parameters but also by subjective parameters influencing sexual life satisfaction. Potential postoperative sexual complaints, therefore, must also be taken into consideration when making the choice of the most suitable surgical technique and in the pre-operative patient counseling.

Key Summary Points

- To-day, the aim of the stricture repair is not only to reinstate urinary function but also to safeguard sexual activity.
- The most commonly reported sexual problems following anterior urethroplasty include: erectile and ejaculatory dysfunction, penile curvature or shortening, dissatisfaction with genital cosmetic appearance and sensorial impairments of glans.
- The prevalence of post-operative sexual problems may be related to the site of reconstruction (penile or bulbar) and to the technique of urethroplasty employed.
- In penile urethral reconstruction, the wide use of buccal mucosa grafts seems to excel the use of skin flaps which easily distort the cosmesis and elasticity of the penis.
- In bulbar reconstructions, graft augmentation techniques seem to impact less on sexual outcome than excision anastomotic techniques.
- Eventual sexual outcomes should be incorporated in the choice of the optimal anterior urethral reconstruction and in pre-operative patient counselling.

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Tissue Engineering in Urethral Reconstruction

35

Hazem Orabi and Francisco E. Martins

35.1 Introduction

Urethra is the distensible tube that extends from the tip of the penis to the bladder neck. It functions as the pathway of urine in both female and males and semen in males only. It is divided into 2 portions anterior and posterior urethra. It is lined with pseudostratified epithelium except at fossa navicularis (stratified squamous epithelium) and posterior urethra (transitional epithelium) [1, 2]. It is subjected to many incidents during lifetime either congenital maldevelopment as hypospadias or epispadias or acquired diseases include trauma, inflammation, scarring or malignancy. All those events can lead to either obstruction of the urine passage or persistence of abnormal urethra opening not at the tip of the penis.

Many surgical techniques are available to repair urethral stricture or defects including the use of tissue transfer with high success rate. Tissues transferred for urethroplasty includes buccal mucosa, non-hairy skin, bladder or colonic mucosa [3].

However, the use of these tissues is hindered by their availability and morbidities associated with their harvest and transfer [4].

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That is why there was a need for off-the shelf tissue to be used to bridge urethral defects and repair stricture in sufficient amounts and without morbidities. Tissue engineering for urethra has emerged as an ideal solution for that. Tissue engineering follows the principles of cell transplantation, materials science and engineering to would restore and maintain normal tissue and organ function [5].

Different strategies of urethral tissue engineering include the use of scaffolds alone, scaffolds with only growth factors/bioactive molecules or scaffolds with epithelial and muscle cells [6]. In all of those strategies, urethral scaffolds form the cornerstone for the regeneration of healthy urethral tissues.

35.2 Scaffolds

35.2.1 Functions of Urethral Scaffolds

Scaffolds can be stated as an artificial structures capable of supporting three-dimensional tissue formation, that allows cell attachment and migration, delivery and retaining of cells and biochemical factors enable diffusion of vital cell nutrients and expressed products [7].

In urethral tissue engineering, scaffolds provide mechanical support against the collapse, hence maintain the lumen of the future urethral tissue open and patent till full regeneration of the

newly formed tissue. Also, they allow the delivery of both the epithelial and smooth muscle cells to the desired site for repair. By permitting the cell attachment, they help the growth and differentiation of the cellular component of rejuvenated tissues. Moreover, they can be used to deliver growth factors as VEGF (ref) to enhance tissue growth and/or inhibit fibrosis (like with an example and reference) [8–10].

35.2.2 Characters of Ideal Scaffold for Urethra

For any biomaterial used as scaffold in tissue engineering generally, it should be biocompatible, biodegradable and non-toxic with unlimited availability. To be suited for urinary tract reconstruction (urethra, ureter and bladder), it needs to be non-permeable to water, resist encrustations and biofilm formation. To better fit in urethral regeneration, it is required to be pliable, complaint, stretchable and distensible.

The biomaterial should be biodegradable so that it can support the development of the new tissues and be absorbed at the end of this process. This avoids the inflammation and foreign body reaction that eventually may lead to scarring or the urethra. The absorption process of the biomaterial should occur at a rate that follows the rate of regeneration to prevent the mechanical failure of the newly formed segments [11].

The biomaterials provide temporary mechanical support sufficient to withstand in vivo forces exerted by the surrounding tissue and maintain a potential space for tissue development.

Biocompatibility refers to the ability of a material to perform with an appropriate host response in a specific situation [12].

Urethral scaffolds should allow cell attachment, growth and differentiation. It should not be toxic to the surrounding structures or stimulate inflammatory host response especially if it will be implanted near the corpora responsible for erection.

Any biomaterial that will be used for urinary organs regeneration must be waterproof to prevent urine leakage into the developing tissues. Urine is cytotoxic to the growing cells and

additionally, it can cause infection and extensive fibrosis. As the urine contains a lot of solutes, the scaffold should be resistant to encrustations and biofilm formation [13].

Specifically designed for urethral tissue engineering, the scaffold needs to be stretchable and pliable to avoid shearing of the material that could result from stress forces of erections especially in case of penile urethroplasty [14].

Additionally, it is mandated for the scaffold to be compliant and distensible so that it does not form a rigid urethral tube. When urine passes through the rigid tube, there will be some sort of functional obstruction [15].

35.2.3 Types of Scaffolds

They can be classified broadly into natural and synthetic scaffolds.

Naturally derived scaffolds:

- Natural polymer as collagen and gelatin
- Acellular matrices as small intestinal submucosa, bladder submucosa, amniotic membrane, acellular corpus spongiosum
- Silk fibroin
- Self-assembled scaffolds

Synthetic scaffolds:

- Biodegradable as PLG and PLGA
- Non-biodegradable as Poly(tetrafluoroethylene) (PTFE)

Natural polymers as collagen or gelatin cannot be used as scaffold for urethral reconstruction as they are mechanically weak and relatively rapidly biodegradable. Likewise, non-biodegradable synthetic material excites severe inflammatory reaction, infection and scar formation leading to rejection of the implanted scaffold [16].

Acellular Matrices/scaffolds: They are obtained by the decellularization of tissues and organs with removal of cells through different mechanical and chemical processes [17, 18].

They have inherent advantages including similarity in biomechanical properties, presence of

growth factors and structural proteins and availability from either xenogenic or allogenic sources. In a comparison between normal bladder tissue and acellular bladder matrix, strain, stress and elastic modulus were similar between them [19].

Growth factors have been found in SIS as TGF beta, FGF-2 and TGF and in bladder acellular matrix as VEGF and PDGF-BB [20, 21].

Organ specific acellular matrices are preferred over non-organ specific matrices. In this context, bladder and corpus spongiosum acellular matrices are preferred over SIS [22].

However, certain limitations exist with acellular scaffolds. The immune response is so intense that leads to severe inflammation and toxicity of the growing cells ending in fibrosis and urethral stricture. This may be attributed to residual cellular fragments after decellularization [17].

Nevertheless, the new commercial bladder acellular matrix has been found to have better immune response [23].

Addition of stem cells can help to modulate the immune response to acellular scaffolds. Although rare, there is a risk of infection with prion viruses especially with SIS [14].

Moreover, the size of the pores may not allow much infiltration of seeded cells into the scaffolds in case of using it as cell seeded graft. This is especially critical for smooth muscle cells which forms muscular layer that allows the regenerated tissues to be elastic, robust, prevent collapse, withstand the pressure during urine flow and prevent adhesions [24].

It seems that bladder acellular matrix would be the best available option as a scaffold for urethral reconstruction being organ specific, availability in sufficient amounts (from porcine bladder) and relatively less immunologic reaction.

Synthetic polymers like polylactic acid (PLA), PGA (polyglycolic acid), PLGA (poly lactic-co-glycolic acid). They have certain advantages including unlimited supply and ability to control porosity, ultrastructure and biomechanical properties, and degradation rate. They still lack intrinsic biologic activity mainly growth factors and proteins needed for cell attachment and migration [25].

Polyglycolic acid:poly(lactide-co-glycolide acid scaffolds been used in clinical studies as

tubular cell seeded grafts to bridge urethral defect ranging 4–6 cm [26].

Self-assembly scaffolds: They are scaffolds made by the deposition of extracellular matrix by stromal/fibroblast cells without exogenous materials. These scaffolds have many advantages including lack of immunologic reaction, having fibroblast cells with cell signaling and presence of many growth factors. However, there are some shortcomings concerning the need for biopsy to extract the stromal cells and relatively less favorable biomechanical features necessary for complex urethral reconstruction [6].

35.3 Approaches for Urethral Tissue Engineering

There are 2 main approaches for urethral regeneration; onlay/partial and tubularized/circumferential urethral replacement. Onlay urethral replacement requires at least half of urethral circumference is healthy so that it acts as a source of healthy cells to migrate and repopulate the scaffold [27].

Circumferential urethral replacement mandates the tabularized scaffold to be cell-seeded because the longest urethral defect that can be bridged without cells is only 5 mm; otherwise fibrosis will precede full cell growth [28].

If tabularized Therefore, tubularized/circumferential urethral substitution necessitates cell-seeded scaffolds (Fig. 35.1).

35.3.1 Urethral Tissue Engineering Using Acellular Scaffolds

Unseeded SIS and bladder acellular matrix have been employed in many preclinical trials with variable degree of success. Human cadaveric bladder acellular matrix has been tested in few clinical trials. Four patients with a history of failed hypospadias surgery had neourethra created by anastomosing the cadaveric bladder matrix in an onlay fashion to the urethral plate. The created neourethra size ranged from 5 to 15 cm. Three of the four patients had a successful outcome both functionally and cosmetically.

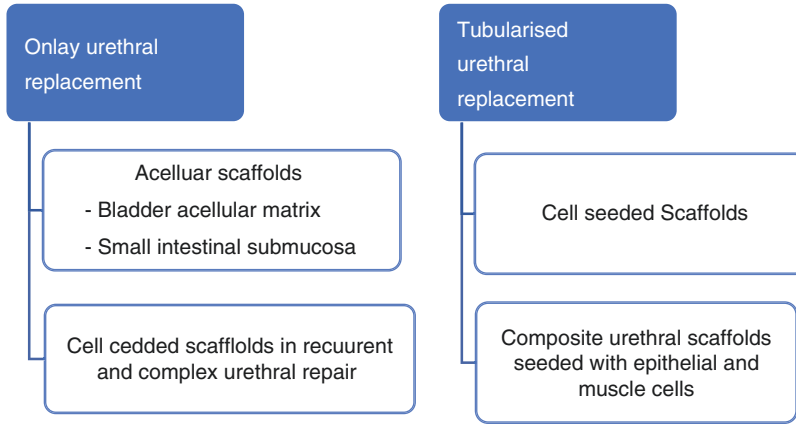


Fig. 35.1 Strategies for urethral replacement with tissue engineering

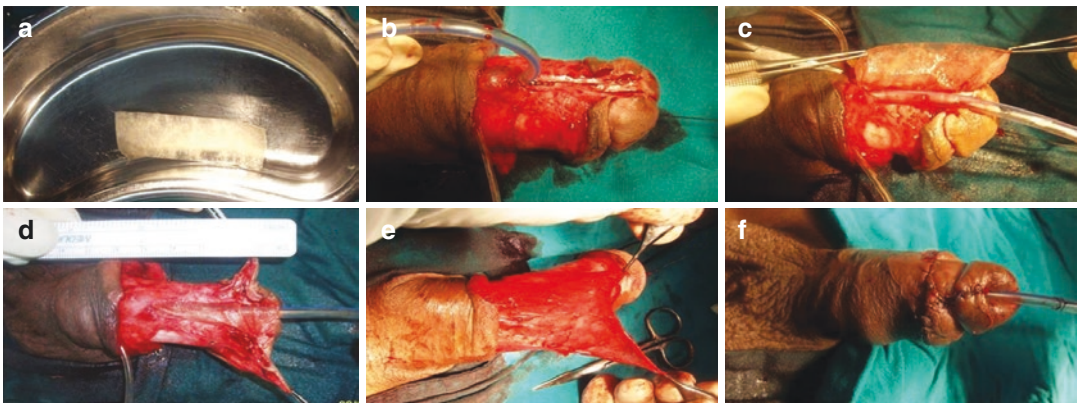


Fig. 35.2 showing brief steps of hypospadias repair with SIS graft. (a) Penile skin degloving through a subcoronal incision preserving the urethral plate. (b) and (c) Suturing of small intestinal submucosa graft to the urethral plate in

an onlay fashion. (d) Mobilization of dorsal penile dartos flap. (e) Splitting of the dartos flap into two equal halves to form second layers coverage for the graft. (f) Final postoperative appearance

One patient with 15-cm neourethra created developed small fistula [29]. As for adults, in a randomized comparative study, El-Kassaby et al. concluded that bladder matrix can be reliably used as a graft biomaterial for urethral repair in stricture patients with a healthy urethral bed while buccal mucosa remains the best graft material for patients with 3 or more prior surgeries who usually have unhealthy urethral beds [27]. As cadaveric bladder matrix cannot be a dependable source of off the shelf material for urethroplasty, commercial porcine bladder matrix was developed. In one of most recent clinical studies using this matrix in 2-stage repair, 8 patients were involved with the length of repair segment ranged from 2.5 to 15 cm. In

7 patients, the acellular graft was well taken and urethra of 4 patients remained patent without the need for subsequent dilation [30].

SIS was used in onlay fashion to reconstruct the urethra in 12 hypospadias patients (Fig. 35.2). Six patients had patent urethra with good cosmetic appearance. Three patients had small fistula repaired with simple closure and three failed [31].

In a study with a long-term follow-up period (71 months), SIS urethroplasty in onlay fashion for urethral stricture was performed. It was successful in 19 patients (76%) and 6 (24%) were failures (100% when the stricture length was more than 4 cm). The clinical outcome was considered a failure when any postoperative instrumentation, including dilation, was needed [32].

Over-all, acellular matrices can be used only as an alternative option in patients with short-to-medium urethral defect with healthy urethral bed and no or minimal spongiofibrosis.

35.3.2 Urethral Tissue Engineering Using Scaffolds with Growth Factors/Bioactive Molecules

Urethral scaffolds alone are thought to be suitable for more simple strictures or defects that need urethral substitution. However, for more complex strictures, other ingredients are needed to be added to the biomaterial. These ingredients are either cells, growth factors or bioactive molecules. The role of the growth factors/bioactive molecules is either to promote the cellular growth, vascularization or inhibit fibrosis and stricture recurrence.

In one study, gelatin scaffold was manufactured with controlled release of epidermal growth factor (EGF) and mitomycin C (MMC). It was designed in a way EGF to be release early and MMC released later. When tested in vitro, EGF promoted urothelial cell growth while MMC inhibited fibroblast growth. The logical controlled release of these molecules in addition to its maintaining its biomechanical properties carry potential for urethral tissue engineering [9].

Based on the fact that excessive deposition of extracellular matrix in the submucosal tissues is responsible for graft fibrosis and stricture, a bioactive molecule that interfere with the pathway of fibrosis was a likely approach. Wnt pathway inhibitor (ICG-001) which ultimately blocks fibrotic effect of TGF- β pathway; was incorporated into collagen/poly(L-lactide-co-caprolactone) (P(LLA-CL)) scaffold. When tested in vitro, there was no negative effect on the urothelial cell growth while there was a notable decrease in release of collagen I, III and fibronectin by the co-cultured fibroblasts. Additionally, when these scaffolds were implanted to bridge urethral defects in rabbits, urethral patency with kept with less collagen and no fistulae [10].

This is approach may be able to bridge the gap between acellular and cellularized scaffolds.

35.3.3 Cell-seeded Scaffold Tissue Engineering Approach

Cell seeded scaffolds approach combines both cells and scaffolds. There are 2 types of cells that can be used for cells seeding; progenitor cells and stem cells.

Progenitor Cells. These cells niches exist in the structure of each tissue and organ. They are characterized by having restricted self-renewal capability and their ability to differentiate into only one defined cell type [33]. Progenitor cells required for tissue engineering of urethra are epithelial cells and smooth muscle cells. These cells when seeded and implanted in vivo, they form waterproof barrier that prevents the urine leak into the tissue inducing fibrosis and restricture formation. Epithelial cells available for urethral bioengineering include urothelial cells from urinary tract, epidermal epithelial cells from skin and oral keratinocytes from buccal mucosa. Bladder and buccal epithelial cells are easier to obtain in sufficient amounts with minimal harvest techniques. Now, bladder epithelial cells can be collected from urine samples or bladder washes. Epidermal cells are nonspecific and usually are not available in situations when urethral tissue engineering is required as recurrent surgery and circumcision.

Smooth Muscle Cells (SMCs): the importance of SMCs inclusion stems from their ability to reduce the inflammatory response after implantation, promote vascularization and smooth muscle regeneration hence elasticity [34].

Stem cells: Stem cells are undifferentiated cells that have self-renewal potential and are able to differentiate into mature nonregenerative cells and effector cells [35]. They are 2 main cells types used in urethral tissue engineering: Adult stem cells and pluripotent stem cells. Adult stem cells can be mainly derived from bone marrow (BM), adipose tissue (ADSCs).

Adipose-derived stem cells (ADSCs) are favored ones as they present in abundant quantities, harvested by a minimally invasive procedure, and differentiated along multiple cell lineage pathways notably smooth muscle cells [36].

Equally important in urethral tissue engineering are the urine derived stem cells (USCs). They can be isolated in sufficient amounts from urine

samples and have the ability for multipotent differentiation. Upon induction with appropriate media *in vitro*, USCs were differentiated into bladder-associated cell types, including functional urothelial and smooth muscle cell lineages [37].

Induced Pluripotent Stem Cells (iPS) Are Reprogrammed Stem Cells from Adult Tissue Such as Skin Fibroblasts, Urinary Tract Stromal Cells and Urine-Derived Cells. They Were Subsequently Differentiated into Urothelial and Smooth Muscle Cells [38]

However, urinary tract-derived iP cells are believed to be of superior differentiation properties to other sources, which should emphasize the epigenetic differences between individual iP cell lines and stress on the importance of organ-specific iP cells for tissue-specific studies [39, 40].

In a canine preclinical study, autologous urothelial and smooth muscle cells derived from urinary bladder were seeded into bladder matrix [24]. These cell-seeded grafts were implanted to replace 6 cm of the whole circumference of the anterior urethra. CT urography showed wide urethral caliber till 1 year postoperative.

One of the most remarkable clinical trials for urethral bioengineering, with important results, is the study by Raya-Rivera et al. [26]. Tubularized polyglycolic acid: poly(lactide-co-glycolide acid) scaffolds were seeded with both autologous bladder smooth muscle and urothelial cells from bladder biopsies. Urothelial cells were seeded onto the luminal surface and muscle cells onto the outer surface of the tubular scaffolds. Five boys with urethral defects ranging from 4–6 cm underwent urethral reconstruction with the tissue-engineered tubularized urethras. The urethra kept patent and functional up to 6 years.

35.4 Preclinical and Clinical Trials with Urethral Tissue Engineering

Many preclinical and clinical studies have investigated the use of urethral scaffolds whether cell-seeded or not [41–43].

While many preclinical and clinical studies have been performed, tissue engineering is not

a routine clinical technique, except for selected recurrent urethroplasties. There is no superiority for any of biomaterials used and more research is needed to determine that [41, 43]. In the clinical settings, a non-seeded scaffold can be used only as an onlay graft. When a tubularized substitution is required, a cell seeded construct have better results [42].

35.5 Challenges and Future Directions

The ideal biomaterial is not yet to be designed. It should have all favorable characteristics. Since tissue engineering will be necessitated in complex urethral strictures and defects with unhealthy vascular bed. This requires good vascularization of the graft through addition of VEGF or endothelial cells [44].

Consistent production of long segments of urethral scaffolds is another requisite. This has been overcome with 3D printing. Tissue bioprinting involves direct printing of living tissues.

in a 3D manner in order to produce a complex structure simulating the original organs. Unlike other AM methods, it involves incorporation of cells, growth factors, and biomaterials.

simultaneously in a one-step approach [45].

PCL/PLCL (50:50) spiral scaffold was printed with bladder epithelial cells and smooth muscle cells loaded in hydrogel [46].

So, the best scaffold for hollow organs in general and urethra specifically would be a combination of both acellular matrices with biological activity and favorability for epithelial growth and synthetic polymers with great porosity for smooth muscle cell and better biomechanical characters. Eberli et al. designed composite scaffolds made from ABM and PGA that maintained ideal physical and structural features both *in vitro* and *in vivo* [8, 47].

35.6 Conclusions

Although urethral reconstruction by tissue engineering has been extensively studied in laboratory animals and human patients and

the search for a tissue/engineered substitute has made considerable advances in the recent years, this technology is still not routinely used in clinical practice. Nonetheless, the field of tissue engineering is definitely expanding and gradually finding its way into clinical application. There are several distinct approaches ranging from unseeded scaffolds, single cell/seeded scaffolds and stratified cultured epithelium with important implications of the role of each particular graft/substitute on the individual clinical situations, i.e., the potential viability of an acellular graft for a short primary bulbular stricture with little scarred urethral receptor bed, whereas long strictures are probably best managed by cellularized tissue/engineered substitutes. Additionally, eventually the most critical role of tissue engineering substitutes for urethral reconstruction lies in the context of long-segment urethral strictures when native tissue for grafting is scarce. More studies are necessary in urethral reconstruction to assess the real role and benefit of scaffolds and cell sources, for example whether cellular grafts or scaffolds without cells are more appropriate for long-segment strictures. These studies should also investigate the several potential options for scaffolds and stromal cells, or epithelial cells and their clinical application.

Recent advances in urethral tissue engineering such as stem cell differentiation, cell/seeded grafts and scaffolds have provided important developments which apparently will be translated into a routine clinical setting in the future. This challenging and important project is also inherently associated with relevant legal and economical aspects which will determine the practicality of the routine clinical use of tissue/engineered materials for urethral reconstruction.

Currently, the reconstructive strategy followed by clinical urologists for treating anterior urethral strictures continues to greatly depend on the extent of the stricture, underlying etiology, availability of autologous tissue substitutes and the underlying host receptor bed.

Key Summary Points

- The use of oral mucosa graft as substitute material for urethral reconstruction has robustly revolutionized the surgical strategy and outcomes of anterior urethroplasty and is still considered the gold standard substitute material for anterior urethroplasty.
- Oral mucosa has unique biological and structural properties making it a highly versatile and adaptable material that can be used in any reconstructive urethral surgery.
- However, treatment options for urethral strictures and hypospadias are somewhat limited due to inherent constraints of tissue substitutes from other donor origins (e.g., skin, bladder urothelium or oral mucosa).
- Tissue engineering in urethral reconstruction is definitely expanding but still finding its way into a more robust clinical application.
- The potential rational and benefits of tissue-engineered materials are prompt availability and abundance, and absence of donor morbidity
- Tissue engineering solutions have been pursued for several decades within the field of urology in general, and urethral reconstruction in particular; but despite important technical success in the laboratory, routine clinical implementation has been limited.
- Currently, tissue engineering faces some important limitations such as high cost when compared to autologous grafts, time required for the preparation of cell-based tissue-engineered grafts, unavailability as an off-the-shell product, and lastly lack of an international uniform policy/strategy to include a number of different regulatory pathways, which vary in different countries, to ensure

patient safety, product quality and efficacy along the several stages of production, starting from in vitro studies all the way to commercialization.

- Although still experimental, this tissue engineering is exciting, promising and rife with potential. The urological community is cautiously hopeful of its benefits in the treatment of urethral stricture disease in the not too distant future.

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Utility of Hyperbaric Oxygen Therapy in Genitourinary Reconstruction

36

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36.1 Introduction

Hyperbaric Oxygen therapy (HBOT) has a well-established history of improving wound healing. The Undersea and Hyperbaric Medical Society which governs the indications and standards for HBOT has approved its use in air or gas embolism, carbon monoxide poisoning, clostridial myositis and myonecrosis (gas gangrene), crush injury, compartment syndrome and other acute traumatic ischemia, decompression sickness, arterial insufficiencies, severe anemia, intracranial abscess, necrotizing soft tissue infections, osteomyelitis (refractory), delayed radiation injury, compromised grafts and flaps, acute thermal burn injury, and idiopathic sudden sensorineural loss (Table 36.1) [1].

Therapy consists of delivering 100% oxygen during multiple sessions in a pressurized chamber up to 3 atmospheres (ATM) which is the equivalence of being 100 feet underwater. The combination of 100% oxygen at a pressure of 3 ATM increases the plasma oxygen levels 20-fold (60 mL/L from 3 mL/L at sea level). This alone has

Table 36.1 Indications for hyperbaric oxygen therapy [1]

The undersea and hyperbaric medical society approved uses for hyperbaric oxygen therapy
Air or gas embolism
Carbon monoxide poisoning
Clostridial myositis and Myonecrosis (gas gangrene)
Crush injury
Compartment syndrome and other acute traumatic ischemia
Decompression sickness
Arterial insufficiencies
Severe anemia
Intracranial abscess
Necrotizing soft tissue infections
Osteomyelitis (refractory)
Delayed radiation injury
Compromised grafts and flaps
Acute thermal burn injury
Idiopathic sudden sensorineural loss

been shown to keep swine alive who's red blood cells have been removed from circulation [2]. A steep oxygen gradient is formed between tissue and nearby capillaries which not only temporarily enhances oxygen delivery but has also been shown to promote angiogenesis [3, 4]. The mechanism of angiogenesis is not well understood but is believed to be mediated in part by stress from reactive oxygen species and reactive nitrogen species formed during the therapy which serve as signaling molecules in various cascades and pathways of growth factors, cytokines and hormones. These products ultimately improve efficiency of new blood vessel

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Fig. 36.1 Hyperbaric oxygen chamber. (Photo courtesy of Hyperbaric Medicine & Wound Treatment Center of Utah)



growth as well as stimulate and recruit progenitor cells [4] (Fig. 36.1).

36.2 Use in Surgery

As mentioned, one of the approved indications for HBOT includes compromised grafts and flaps. It's believed that the enhanced mechanism of angiogenesis described above hastens necessary granulation and thereby improves graft uptake [6]. Since the 1960's, over 50 animal studies have been performed evaluating the efficacy of HBOT to improve graft and flap healing. These studies have largely shown that HBOT increased capillary network formation when evaluated on micro-angiography, have earlier graft and flap uptake and improved perfusion [7, 8].

Human studies have largely been limited to case reports and retrospective series but have reported positively on enhanced wound healing afforded by HBOT [5, 7]. Only one randomized control trial has been performed to date and was performed in 1967 on 48 patients undergoing split thickness skin grafts. HBOT was delivered at 2 ATM for 120 min twice daily for 3 days. Patients in the HBOT group had 64% complete graft survival compared to 17% in the control group ($p < 0.01$). While the results are dramatically in favor of HBOT, the number of sessions are significantly reduced compared to most regi-

mens today in addition to lower average pressure. Furthermore, the 17% graft survival in the control group is remarkably poor and would be considered unacceptable by today's standards [5].

While the available evidence is practically unanimous in support of HBOT's availability to improve graft and flap survival, it's worth noting that its indications are limited to tissues that are threatened, compromised, or otherwise at risk [6]. Therapy should be timely. A retrospective study on free tissue transfer or replantation noted 89% complete graft viability when HBOT was initiated immediately after surgery, 25% when initiated 1–3 days post operatively, and 0% when started more than 3 days post operatively [8]. In concordance with The Undersea and Hyperbaric Medical Society and expert opinion, HBOT for compromised grafts or flaps should be administered at 2.0–2.5 ATM from 90 to 120 min, initially twice per day but can be transitioned to once daily when the flap or graft appears viable and stable. 30–40 sessions are typically required to meet desired outcomes [6].

36.3 Indications in Urology

36.3.1 Hypospadias Repair

Hypospadias repair is fraught with potential complications including fistula, meatal stenosis, stricture, and dehiscence. Given that in hypospa-

dias repair, adequate vascularity is critical to repair survival and may help reduce the risk of complications, HBOT may have a role in improving outcomes. In a series of 669 pre-pubertal patients undergoing tubularized incised plate (TIP) repair for hypospadias, Bush et al. identified only two independent risk factors for post-operative complications: reoperative TIP (OR 3.07, 95% CI 1.54–6.13) and meatal location (OR 1.79, 95% CI 1.34–2.40) [9]. This has led to some experts proposing HBOT be used in patients undergoing their third or more re-operation [10].

There are a few small series exploring the use of HBOT in hypospadias repair. In a 2014 study out of Turkey, Ateş et al. used 10 sessions of HBOT in 13 patients undergoing proximal and midpenile hypospadias repair with buccal mucosal tube urethroplasty and compared them to 3 patients who did not. In the HBOT group, 5 patients were primary repair and 8 patients were reoperation, with an average graft length of 5.4 cm. In the non-HBOT group, 1 patient was a primary repair and 2 patients were re-operation, with average graft length of 8 cm. The HBOT group experienced 53.8% first stage success and 84.6% second stage success. The three patients in the non-HBOT group had 0% first stage success and 33% second stage success [11]. Though the study is underpowered to make any claims regarding the effectiveness of HBOT in hypospadias repair, it was among the first to demonstrate the potential of its use.

In a 2018 retrospective cohort study, Verhovsky, Bush and Snodgrass et al. compared two groups undergoing two stage hypospadias repairs with either preputial or buccal grafting. Group 1 included 7 patients who underwent HBOT during their repair. These patients had an average of 4 prior operations. Group 2 included 14 patients with an average of 3 prior operations and did not receive any HBOT. Each group was roughly equivalent in severity of hypospadias and prior complications. Group 1 experienced good graft take in 100% (7 out of 7) of patients with two cases needing reoperation (one for meatal stenosis and another for fistula). In group 2, 14 patients underwent 20 operations graft contractions occurred in 40% (8 out of 20). The 6 patient reoperations were due to 4 cases of fistula, 2 of

meatal stenosis and 2 of dehiscence. In all there was a 50% increase in reoperations/complications in group 2 (non-HBOT) [12]. Although, an observational study, this furthers the evidence toward improved outcomes when complimenting repair with HBOT, particularly in patients requiring grafting and reoperation.

While HBOT has shown promise in early studies, its use in hypospadias repair would frequently involve pediatric patients. HBOT in adults is well studied and generally well tolerated; however, its use in the pediatric population can pose challenges. Few centers are equipped to manage pediatric patients, and the patients may not always be able to convey potential complications they're experiencing. A 54-patient series of patients 3 months to 16 years old found overall HBOT was well tolerated in this age group. Potential complications include oxygen toxicity convulsion (0.3% of treatments), progressive hypoxemia (0.3% of treatments), and brief hypotension (0.6% of treatments) [13]. HBOT appears to be a feasible option in both adults and pediatric patients where available.

36.3.2 Urethral Stricture

Urethral stricture repair has several known potential complications including re-stricture, post-micturition dribbling, and erectile dysfunction (ED). Rates for each have been reported to vary from 10–20% depending on stricture location, length, and other risk factors [14, 15]. A 2013 metaanalysis investigating *de novo* rates of erectile dysfunction after anterior urethroplasty found the incidence to be 1–3%, and up to 86% of the time, ED was self-limited and resolved within 6–12 months [15]. Though anterior urethroplasty has a limited durable impact on erectile function, posterior urethroplasty rates carry a 2–5% risk of *de novo* ED [16].

A 2010 study randomized men to HBOT or nothing following posterior repair. The HBOT group received 14 treatments starting post-operative day 1. International Index of Erectile Function (IIEF) was used to assess erectile function preoperatively and at 3 months. Patients in the HBOT group reported a significantly higher

overall IIEF score, as well as scores in the erectile function, overall satisfaction, and intercourse satisfaction. Stricture recurrence rates were not assessed [17]. It's worth noting that 3 months may be insufficient follow up to suggest HBOT has a role in this setting given historically, ED requires 6–12 months to assess resolution. HBOT has been shown to improve fascial nerve regeneration and it's reasonable to expect hastened and improved recovery of ED in the setting of stricture repair via enhanced angiogenesis and nerve regeneration [18].

There is paucity of data describing the use of HBOT in treating urethral stricture disease itself or preventing recurrence. A retrospective cohort of 25 patients undergoing HBOT for radiation injuries included 5 patients who were treated for urethral stricture. Four of the 5 patients saw improvement of the stricture with HBOT (1 with “major” response, 3 with “minor” response) while 1 patient experienced stricture progression. The study was not designed to measure stricture specific improvements and no details were provided on how HBOT was used in this setting, and what, if any, other treatments were used [19]. Though the data are limited, extrapolating the known benefits of HBOT toward stricture disease, there is likely a role for HBOT, particularly in threatened tissues.

36.3.3 Urologic Fistula

Urologic fistulae are a rare though unfortunate potential side effect of pelvic radiation. Common sites of fistula formation include rectourethral, rectovesical, vesicocutaneous, enterovesical, and fistula from bladder to abscess. Fistula formation is often associated with an inciting event in radiated patients such as rectal biopsy, TURP, and performing clean intermittent catheterization [20]. Management varies on fistula size and location and can involve partial bowel resection, urinary diversion or fecal diversion. There have been few case reports and series evaluating the use of HBOT in treating urologic fistula [21].

Marguet et al. described 4 patients with rectal ulceration at risk for fistula formation. Patients

had temporary urinary diversion with urethral or suprapubic catheter and underwent a mean of 50 HBOT sessions. All 4 patients had progression from rectal ulcer to rectourethral fistula after at least 40 HBOT sessions [22]. Another study involved 3 patients with rectourethral fistula following radiation therapy that underwent suprapubic tube placement and HBOT. Two of the 3 patients had eventual resolution of the fistula over 19–21 months [23].

The limited data is mixed regarding the effectiveness of HBOT with temporary diversion for the treatment of rectourethral fistula in patients with history of pelvic radiation. While there may be a role for HBOT in this setting, 19–21 months for complete resolution may be reason for some to favor earlier more definitive, albeit invasive, treatments.

36.3.4 Radiation-induced Hemorrhagic Cystitis

Radiation-induced hemorrhagic cystitis (RHC) occurs with a frequency of 3–6.5% following pelvic radiation and can present from at any time from 6 months to 20 years following radiation therapy [24–26]. RHC can be a tremendous burden to patients requiring multiple hospitalizations for active bleeding, clot urinary retention and transfusions. Some series have reported an associated mortality up to 44% [27]. Therapeutic options are varied but no large prospective study has been performed to date.

A 2018 meta-analysis evaluated HBOT for the treatment of RHC. Sixteen studies with a total of 602 patients who received HBOT for RHC were included. Pooled analysis found 84% (95% CI 76–91%) of patients had at least a partial to complete response to HBOT. Only 14% of patients who responded to HBOT experienced a relapse of symptoms with a median time of relapse of 10 months following HBOT. Predictors of HBOT success included increased number of sessions, a lower (better) Toxicity criteria of the Radiation Oncology Group (RTOG)/European Organization for Research and Treatment of Cancer (EORTC) score, lower RT dose, younger

age, and HBOT initiated within 6 months of symptom onset [28].

Though HBOT comes with a significant cost and time commitment, the potential for durable response, particularly when initiated early, makes HBOT an attractive option for RHC.

36.3.5 Fournier's Gangrene

Fournier's Gangrene is a necrotizing fasciitis of the genitals, perineum or perianal regions. It is an aggressive infection with mortality rates varying from 7–40% across the literature [29]. Infections tend to be polymicrobial and can consist of aerobic and anaerobic organisms [30]. Treatment recommendations are varied but generally consist of early initiation of broad-spectrum antibiotics and surgical debridement of necrotic and devitalized tissue. Following debridement and depending on defect size, there are various options for wound closure including flaps, grafts, and wound VAC [31–33]. HBOT has been utilized by many centers to enhance wound healing and improve infection control [29, 34, 35].

HBOT has been shown to improve efficacy of some antibiotics and can be therapeutic against anaerobic organisms by significantly increasing oxygen delivery to threatened tissues [34]. HBOT encourages aerobic respiration in many pathogens, and increases reactive oxygen species formation, a process which several antibiotics depend on for efficacy [36, 37]. Fluoroquinolones, Penicillins, Aminoglycosides and Carbapenems all have a theoretical potential to be enhanced by HBOT [36–39]. The ability of HBOT to improve infection control in Fournier's gangrene remains theoretical as no study to date has validated the potentiation of antibiotics by HBOT in this setting.

While there are no prospective randomized trials investigating HBOT use in Fournier's, retrospective studies do not support its use. Mindrup et al. retrospectively reviewed 42 consecutive patients treated for Fournier's gangrene at their institution, 26 of the patients were treated with HBOT for a median of 6 treatments (range 2–26) in addition to standard therapy, and the remaining

16 patients underwent standard treatments alone. There were no significant differences in patient characteristics and comorbidities between the two groups, including number of debridements or split-thickness skin graft size. The decision to use HBOT was up to the treating surgeon. The results of the study showed no differences in outcomes between the two groups including graft survival, disease specific mortality, duration of hospital stay or complications. The only significant finding was patients in the HBOT group had a roughly \$1000 increase in daily hospital charges. It was also noted that delivering HBOT to patients in the inpatient setting, particularly in the immediate postoperative period can be difficult and dangerous [35].

Given the lack of compelling evidence and significant cost and time burden, HBOT use in Fournier's remains experimental and is best reserved for refractory cases, or patients at high risk for impaired flap or graft healing.

36.4 Conclusions

Overall the evidence underlying the use of HBOT in reconstructive urology is restricted to case series and retrospective observational studies. Some studies point to the possibility of improvement in the outcomes of reconstructive surgery with compromised vascularity, such as hypospadias repair with using HBOT in an adjuvant setting. Across the various uses of HBOT explored in this review, themes for favorable application include prior radiation exposure, threatened flaps or grafts, and early initiation of HBOT therapy when it's indicated. Though insurance coverages vary, it's important to consider the cost of HBOT which is around \$20,000–\$50,000 US dollars for 30 or more sessions [25, 40]. Finally, while complications of HBOT are rare, they include barotraumatic otitis and sinusitis, visual disturbances, dizziness, and limited therapy due to claustrophobia (Table 36.2) [41, 42]. Prospective studies should be encouraged for the use of HBOT as an adjunct in surgery, particularly in difficult reconstructive cases, where any improvement in outcomes would have substantial benefit to patients.

Table 36.2 Side effects and complications of hyperbaric oxygen therapy per session [42]

Side effect	Frequency (%)
Barotrauma	13
Hypoglycemia	0.4
Seizures	0.3
Dizziness	1.5
Claustrophobia	0.3
Chest pain	0.9
Dyspnea	0.3
Vision changes	0.3

Key Summary Points

- Only 1 randomized control trial has been performed to date (1967) evaluating HBOT use with surgery which demonstrated improved survival of split thickness skin grafts treated with HBOT.
- HBOT may improve flap and graft survival.
- HBOT may improve outcomes of hypospadias repair, particularly repeat repairs.
- HBOT may hasten return of erectile function following repair of urethral stricture.
- HBOT improves radiation-induced hemorrhagic cystitis in 84% of patients.
- There is no compelling evidence in favor of HBOT use in the treatment and repair of Fournier’s gangrene or urinary fistula.
- HBOT is best supported in patients with prior radiation exposure or threatened flaps or grafts and should be initiated early when indicated.

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Part II

Penile and Scrotal Reconstruction

Penile, Scrotal, and Perineal Anatomy for the Reconstructive Surgeon

37

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37.1 Penis

The penis can be divided into three components: posterior (root), central portion (shaft), and anterior (glans). The posterior penis is anchored to the anterior pelvis via the suspensory penile ligament and further secured circumferentially by the fundiform ligament (of Luschka). The shaft is made up of three cylinders: the paired dorsal corpora cavernosa and the corpus spongiosum. The corpora cavernosa provide the attachments to the pubic bone and fuse at the crus. Throughout the shaft, there is an incomplete, permeable septum that separates each of the corpora cavernosa that allows vascular communication between the two [1]. The pendulous or penile urethra travels through the corpus spongiosum. All three cylinders are encased in Buck's (deep) and Dartos (superficial) fascia. The glans penis is a continuation of the corpus spongiosum. [1] The corona separates the shaft of the penis from the base of the glans.

The penis is supplied by two arterial systems: superficial and deep. The superficial system arises from the external pudendal artery, whereas the deep system originated from the internal pudendal artery [1]. The internal pudendal branches supply the majority of the

penile structures, giving rise to the common penile artery. The common penile artery travels in Alcock's canal and divides into the bulbourethral artery, cavernosal artery and the dorsal penile artery. The bulbourethral artery enters the corpus spongiosum from its posterolateral border and supplies the glans, urethra, and corpus spongiosum [1]. The cavernosal artery enters the penile hilum and supplies the cavernosal sinuses that engorge with erection. The dorsal penile artery travels between the crus and the pubis, continuing proximally with the dorsal vein and dorsal penile nerve [1]. It supplies the dorsal corporeal bodies and provides redundant blood supply to the urethra and corpus spongiosum via circumferential branches [1]. This will be touched upon later in the urethra section of this chapter.

Buck's fascia separates the superficial dorsal vein from the deep dorsal vein. Both veins drain into the preprostatic plexus. Somatic innervation of the penis derives from the pudendal nerve, which travels through Alcock's canal and continues as the dorsal penile nerve. The dorsal penile nerve's terminal branches are responsible for sensation of the entire penis [1]. Autonomic input to the penis arises from the pelvic plexus and cavernous nerves, which enter the penis at the level of the corporeal bodies. The cavernous nerve supplies both the parasympathetic and sympathetic innervation, responsible for tumescence and ejaculation, respectively [1].

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Two layers of fascia surround the penile shaft: Buck's fascia and tunica albuginea. Many pathological conditions disrupt the integrity of the tunica albuginea including Peyronie's disease and penile fracture. The tunica albuginea has an outer longitudinal and an inner circular layer both with varying thicknesses. The outer layer is chiefly responsible for the tensile strength and thickness of the tunica [2]. The combined tunica is thinnest in the three and nine o'clock regions whereas at the five and seven o'clock positions, there is no longitudinal layer whatsoever [1, 2]. The tunica layers are separated by an incomplete septum that provides further anchoring and strength [1].

The primary pathological process in Peyronie's disease is the development of a plaque in the tunica albuginea that forms secondary to repeated microtrauma, commonly from sexual intercourse, and results in penile curvature. Depending on the location of the plaque, the degree of curvature, and the patient's erectile function, surgeons can choose between tunical plication, plaque incision or excision with or without grafting. For full

access to the tunica, many surgeons advocate degloving prior to repair. This can be done with a circumferential incision made 1–2 cm proximal to the corona. The skin and underlying tissue down to Buck's fascia is released and mobilized to the base of the penis using a sponge [3]. Alternative approaches involving full penile exposure using a penoscrotal incision has been described as well [4]. In penile plication the sutures are thrown longitudinally through the tunica albuginea (Fig. 37.1a–c) but not the underlying corpus cavernosa to correct the curvature as described by Cordon et al. [5].

One of the challenges with more invasive approaches to Peyronie's disease is how to address the dorsal neurovascular bundle. It is typically located beneath Buck's fascia along the tunica of the corporal body, extending from the eleven and one-o'clock positions to the junction of the urethral spongiosum [6]. The nerves from the bundle penetrate into the erectile tissue in the ventro-lateral aspect of the proximal crural bodies in the posterior penis [6]. Based on this anatomical prin-

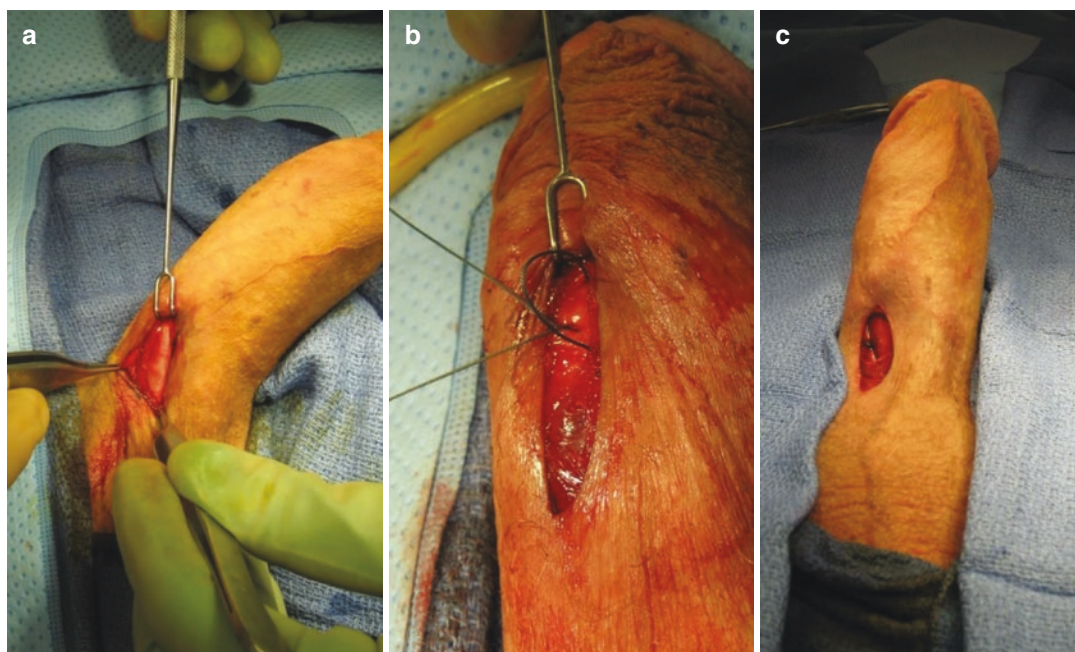


Fig. 37.1 Penile plication for Peyronie's (a) The penile tissues are dissected to the level of the tunica albuginea. (b) Sutures are placed longitudinally through the tunica

albuginea but not through the corpus cavernosa. (c) Sutures are tied tightly to correct the curvature

ciple, Aklulut et al. discussed that the bundle could be successfully mobilized using either a lateral or a medial approach to the dissection. In the lateral dissection, Buck's fascia is incised at the 5 and 7 o'clock positions and is removed towards the 11 and 1 o'clock positions [7]. An Allis clamp is applied to the tunica of both corpora and the excision is carried out. In a medial approach, Buck's fascia is opened at the dorsal aspect of the penis and the deep dorsal vein is removed at the area of maximal curvature [7]. The neurovascular bundle is then minimally dissected in a medial-to lateral fashion, Allis clamps are applied to the tunica in the bed of the neurovascular bundle, and excision is completed (Fig. 37.2). The authors found that the medial dissection had longer operative times and a higher incidence of postoperative penile shortening but noted no significant difference in postoperative glans sensory loss [7].

With regard to inflatable penile prosthesis (IPP) surgery, there are several anatomical pearls to consider. In the penoscrotal approach, a 4 cm transverse incision is made about 1–2 cm below the penoscrotal junction measured with the penis

on stretch superiorly, as seen in Fig. 37.3a [8]. We suggest making the corporotomy proximal enough so that the device tubing exits the cylinder into the scrotum and not the penile skin and making the corporotomy about 1.5 cm in length (Fig. 37.3b) [8].



Fig. 37.2 Dissection of neurovascular bundle. Allis clamps are used to isolate and control the neurovascular bundle within the Buck's fascia during Peyronie's correction

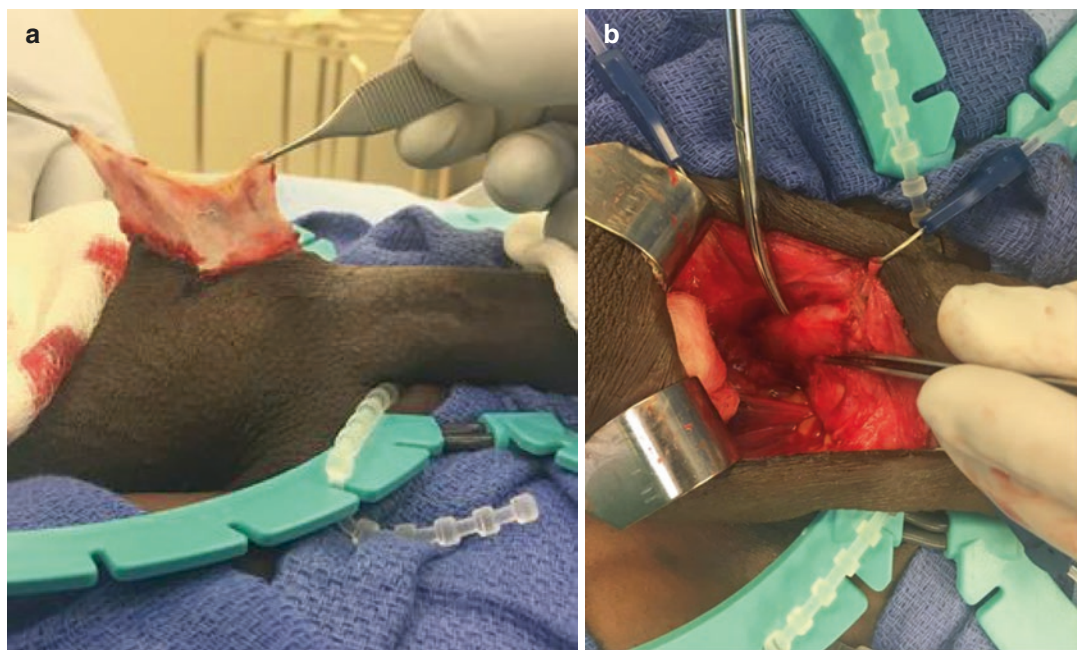


Fig. 37.3 IPP insertion via penoscrotal approach. (a) Penoscrotal incision made 1–2 cm below the penoscrotal junction with penis on stretch. (b) Location of proximal corporotomy for cylinder insertion

When considering reservoir placement, the ideal location for the un-violated space of Retzius is just lateral to the pubic bone. This is accomplished by placing a retractor in the external inguinal ring, retracting the anterior wall of the inguinal canal anteriorly, and developing the plane lateral to the pubic bone with blunt dissection. [8] There are important anatomic considerations at the time of penile implant reservoir placement into the retropubic space. Prior investigations have shown that bladder decompression and avoiding deep dissection lateral to the inguinal ring were key in avoiding the external iliac vein [9]. At our institution, we do not commonly use Trendelenburg positioning; however, in instances of obese patients or those with anatomical constraints we will flex the bed in order to allow for easier palpation of the inguinal ring. We commonly use a finger to violate the transversalis fascia and purposefully avoid use of sharp instruments to avoid injury to pelvic vasculature while the reservoir is placed in the plane created between the pubic bone and the transversalis fascia [8]. Placing the pump requires that an additional 1 cm incision made in the scrotum and scrotal fascia,

and bringing the scrotum upward through the incision so that the pump may be placed in an accessible, gravity-dependent location [10].

In the infrapubic approach, the incision is made one fingerbreadth superior to the penopubic junction while the penis is on downward traction [11]. The corpora are accessed by creating a defect in Scarpa's fascia, bluntly sweeping down along either side of the penis, and gently pushing down with a small retractor [11]. The reservoir is placed in a similar location as described above by placing a nasal speculum in the external inguinal ring and perforating the transversalis fascia. This will develop the space just anterior to the pubic bone and posterior to the transversalis fascia. To place the pump, a nasal speculum is used to penetrate Colles' fascia and the pump is placed in a midline and gravity dependent position [11].

The artificial urinary sphincter (AUS) remains the standard of care for moderate-severe urinary incontinence in appropriately selected male patients [12]. In first-time patients, the cuff should be placed as proximal on the bulbar urethra as possible near the area of the crus (Fig. 37.4a) [13]. The bulbospongiosus muscle

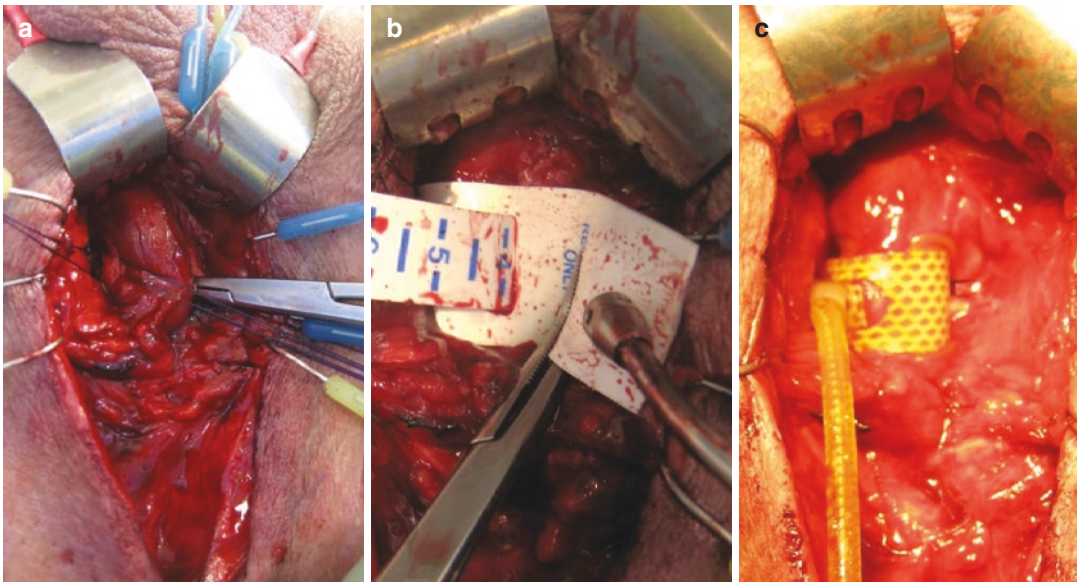


Fig. 37.4 Artificial urinary sphincter. (a) Primary AUS implantation should be as proximal on the bulbar urethra as possible. (b) After dissection a circumferential mea-

surement is taken of the corpus spongiosum. (c) The pressure cuff is placed around the spongiosum

and tunica albuginea and systematically and sharply dissected off the urethra until the urethra can be completely encircled with a vessel loop and inspected for injury [13].

After inspecting the urethra for injury, a circumferential measurement is taken around the corpus spongiosum, which commonly measures between 3.5 and 5 cm (Fig. 37.4b) depending on various patient factors including patient age, previous prostatectomy, and erectile function [12, 14]. The cuff is then implanted (Fig. 37.4c). The pressure-regulating balloon is placed deep to the transversalis fascia using either an inguinal, midline, or scrotal incision [13]. Similar to the pump placement for an IPP, the AUS pump is placed in a gravity-dependent portion in the scrotum by inverting the scrotum into the groin incision and guiding the pump to its location after dividing the Dartos fascia [13].

37.2 Urethra

The male urethra originates from the pelvic and phallic portions of the urogenital sinus and are split into the prostatic, membranous, and spongy (cavernosal) urethra, which is further subdivided into the pendulous and bulbous urethra. Strictures

can form throughout the entire course of the urethra and its surrounding corpus spongiosum. Typically patients present with weak stream, straining during voids, recurrent urinary tract infections, and urinary retention. Urethral stricture disease is relatively uncommon, affecting approximately 0.6% of men, more commonly those >65 years old [15]. Strictures can form anywhere along the course of the urethra, although they most commonly form at the bulbar urethra from traumatic catheterization/cystoscopy/other surgical intervention or unrecognized trauma [16]. The rationale behind this is that the support of the penis at the penoscrotal junction acts as a fulcrum around which instrumentation of the urethra can cause unintended trauma [16].

Treatment and repair of these strictures can be quite costly, totally \$191 million in 2000 [17]. Dilation and direct vision internal urethrotomy (DVIU) are commonly the first line therapy for treatment of strictures, particularly those <1.5 cm in length [16]. However, stricture disease is often more than just narrowing of the urethra itself and often includes scarring of the surrounding corpus spongiosum, which is referred to as spongiofibrosis (Fig. 37.5a, b). Dilation, which we recommend only be attempted via radial balloon dilation as opposed

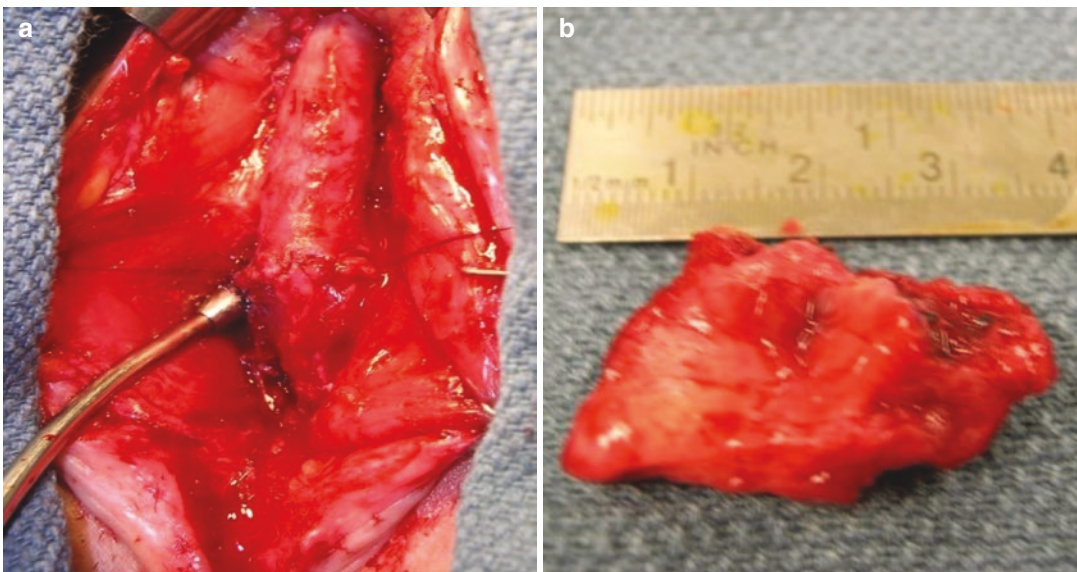


Fig. 37.5 Spongiofibrosis. (a) Urethra with prominent spongiofibrosis (b) excised urethra and spongiofibrosis

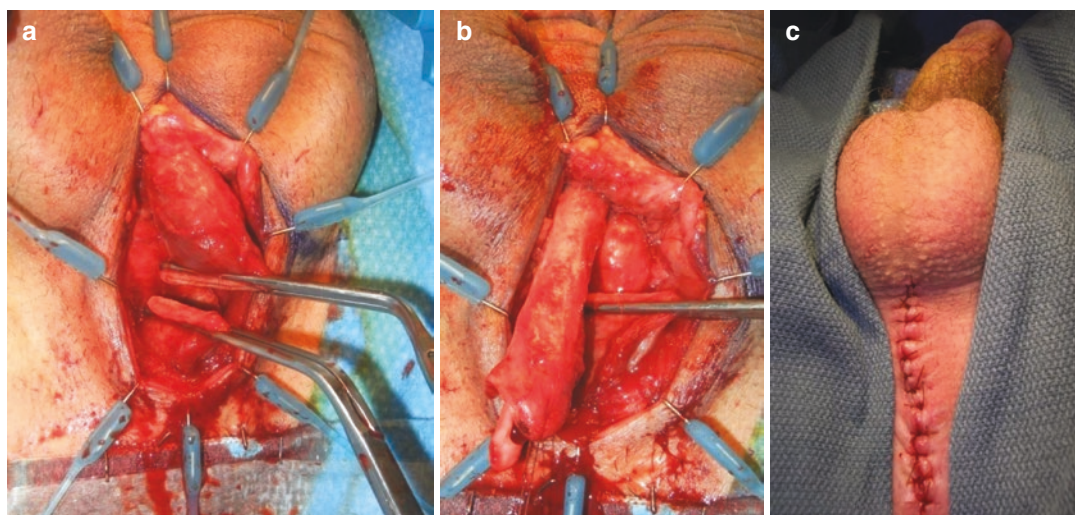


Fig. 37.6 Excision and Primary Anastomosis Urethroplasty (EPA). (a) Isolation of urethral stricture. (b) Distal portion of urethra on stretch. (c) Closure of perineal incision

to urethral dilators which are prone to creating false passages, only transiently addresses the urethral scarring and not the underlying spongiofibrosis [16]. DVIU on the other hand can treat superficial (i.e. more proximal to the urethral lumen) spongiofibrosis. However, both of these minimally invasive techniques lack long term efficacy, with only a 0–30% success rates being reported at four years post procedure [18]. There are also several papers which show repeat dilation or DVIU have zero success beyond 2 years [19, 20].

Urethral reconstruction on the other hand offers significantly improved treatment success rates. Regardless of the reconstructive technique employed, in order to ensure proper healing, great respect must be paid to the vascular structures supplying the repair. This is particularly true when the success of the surgery depends on the uptake of a graft to ensure the patency of the lumen. The blood supply to the urethra is derived from the corpus spongiosum which itself has a dual blood supply; receiving antegrade flow from the urethral and bulbar arteries, two of the four branches of the common penile artery (a branch of the internal pudendal), and retrograde flow through the anastomoses of the deep dorsal and urethral arteries. The other branches of the common penile artery are the dorsal artery of the penis and the cavernous

sal artery, which is important because the dorsal artery also supplies supplemental blood flow to the urethra through circumflex arteries. Retrograde flow is of particular importance in excision and primary anastomotic urethroplasties (EPA, Fig. 37.6) as the urethral artery is transected and would otherwise leave the distal urethra without blood supply [1, 21].

Of the anterior urethra, the bulbar urethra has the most redundant tissue and is a prime location for EPA and non-transecting bulbar urethroplasties. As the name implies, EPA urethroplasties involve complete excision of the strictured urethra and anastomosis of the unaffected ends (Fig. 37.6a, b). Due to tension concerns, EPA was originally only used for <2 cm strictures [22]. However, more recent reports have shown that EPA can successfully be used for up to 5 cm bulbar urethral strictures as the redundant tissue can be stretched (Fig. 37.6b) [23, 24]. The retrograde blood flow of the corpus spongiosum discussed earlier is of great importance for these repairs, but patient selection is paramount. Patient that are elderly, have vascular disease, prior hypospadias repair, previous urethroplasty, and those who have artificial urethral sphincters (AUS) are all at risk of having impaired retrograde flow and thus risk theoretical necrosis of the urethra or erosion of AUS into the urethra [21, 22].

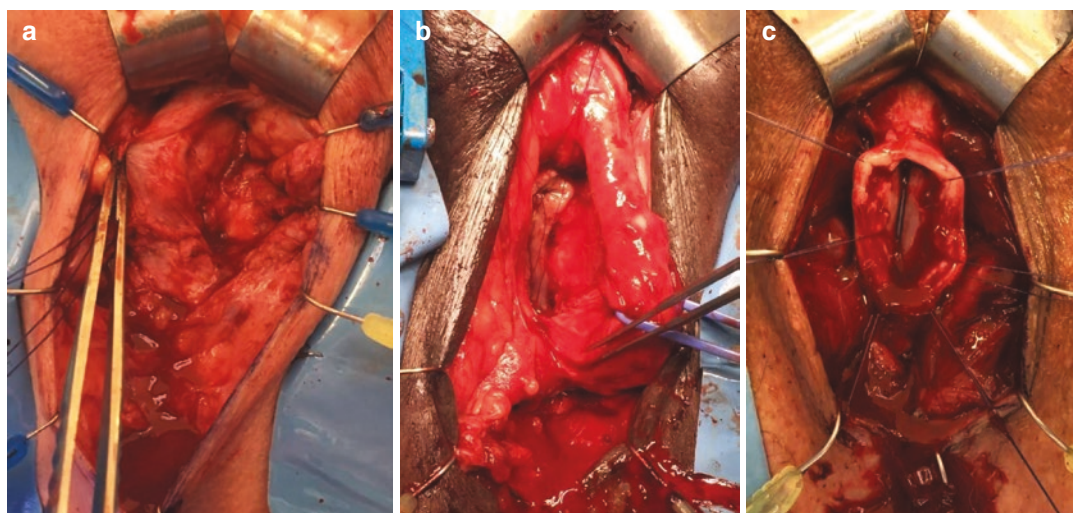


Fig. 37.7 Augmentation urethroplasty with grafts. (a) Isolation and mobilization of corpus spongiosum. (b) Exposure for dorsal onlay urethroplasty. (c) Exposure for ventral onlay urethroplasty

By employing non-transecting techniques, one can preserve the urethral artery and key anatomic features of this repair are discussed below. In this method, the subcutaneous tissues and Colles' fascia of the perineum are transected to expose the bulbospongiosus muscle. The Gallaudet's fascia, which lies between the bulbospongiosus muscle and the bulbar urethra on the dorsal surface is then opened to expose the bulbar urethra. In opening only the dorsal urethra, the blood supply on the ventral spongiosum is not interrupted. It is then mobilized from the attachments to the corpora cavernosa tunica albuginea, up to the perineal membrane. The bulbar urethra is then incised longitudinally and closed transversely, in a Heineke-Mikulicz fashion [22, 25]. This repair has been shown to be successful in bulbar strictures <2 cm in length as well as for thin strictures only a membrane in thickness (i.e. for stricturoplasties) [22].

For strictures >2 cm, grafts must be employed to ensure urethral patency (Fig. 37.7a–c). As outlined previously in this text, there are a variety of techniques and substrates used urethral grafting. Techniques such as the classical Barbagli involve complete mobilization of the urethra from the corpus spongiosum and a graft is then laid dor-

sally onto the urethral plate (Fig. 37.7b) [26]. The dorsal urethra is then incised longitudinally and the sides of the graft are sutured onto each side of the urethrotomy. The Asopa (dorsal inlay) is a modified version of this technique where both the ventral and dorsal urethra are incised approximately 1 cm on either end of the stricture and a graft is transplanted onto the urethral plate through a dorsal urethrotomy. The corpora play an important role in this urethroplasty technique as they provide a rigid body onto which the graft is tacked for needed blood supply. Asopa urethroplasty should only be considered when the urethral plate is >5 mm as anything narrower leaves little vascularity to supply the graft and makes suturing the graft into place technically difficult if not impossible. The classical Barbagli and Asopa techniques both have very high patency rates of >85%, but the Asopa is technically easier, requires less operative time, and has less blood loss as it requires significantly less mobilization of the urethra [21, 27, 28]. The more modern Barbagli technique of a ventral onlay (Fig. 37.7c) is employed in bulbar urethral strictures where the spongiosum is incised and only the ventral aspect of the urethra is opened to permit a free graft of buccal mucosa [29].

37.3 Scrotum and Perineum

Compared to urethral reconstruction and other penile/perineal surgeries, scrotal surgeries tend to be more simplistic and forgiving. As a loose bag of skin, the scrotum itself is one of the most forgiving tissues in the body to work with surgically. However, the loose nature of the scrotum can also be vexing, as evidenced in cases of scrotal hematoma as they can become quite large and slow to drain. From outward to inward, the scrotum consists of two layers: skin and Dartos fascia, which is also the superficial fascia of the penis and is a continuation of the abdominal wall's Scarpa's fascia and perineal Colles' fascia. Deep to these structures lie the spermatic cord and its contents: external spermatic fascia (a continuation of the external oblique fascia), cremasteric muscles (continuation of the internal oblique), internal spermatic fascia (continuation of the transversalis fascia), and the parietal and visceral layers of the tunica vaginalis, which encompass the testicle, epididymis, vas deferens, testicular artery, and pampiniform venous plexus [30, 31]. The superficial Dartos fascia also forms an avascular median plane between the hemiscrotums, which makes the median raphe a useful location for many transscrotal incisions. Respect must be paid to each of these layers during dissection as the individual layers should be closed separately [21]. Through these layers, the scrotum provides protection to the testicles contained within, as any force applied to the scrotum is spread through these layers before reaching the testicles [31]. The potential space between the layers of the vaginalis is where hydroceles form. It is important when treating a hydrocele to investigate its communicating potential with the peritoneum (i.e. if there is a patent processus vaginalis) as they can coincide with inguinal hernias. If this is encountered, both should be repaired simultaneously [21, 31].

The tunica albuginea is a tough fibrous layer that covers the testis and is lined internally by the tunica vasculosa and encompasses all but the posterior testis. Within the tunic albuginea lie lobules of seminiferous tubules which contain the Sertoli and Leydig cells responsible for sperma-

tozoa formation [31]. During trauma or debridement of infectious/necrotic tissue, should the testicular tissue appear viable, all attempts should be made to close the tunica albuginea primarily and preserve the testicle due to the blood supply from the testicular/gonadal artery (a branch directly off of the aorta) [21, 32–34]. The epididymis sits along the entire length of the posterior testis before giving rise to the ductus deferens/vas deferens [31].

The same principle of robust blood supply holds true for the scrotum itself. Blood vessels to the scrotum are branches off the pudendal artery, a terminal branch of the anterior division of the internal iliac artery [30]. The external pudendal feeds the penile skin and anterior scrotal wall via the anterior scrotal artery network whereas the posterior scrotal wall is fed by the posterior scrotal artery, which is a branch of the perineal artery. When performing dissections of the proximal bulbar urethra, one must take great care in not severing the perineal artery which lies between the bulbospongiosus muscle and intercavernous septum [21]. The scrotal arteries form a subdermal plexus of vessels, making it an excellent substrate for urethral reconstruction and penile flaps; however, one needs to ensure that the base and lateral sides of any flap are maintained so that adequate arborization is preserved. When forming these flaps, take advantage of the relatively avascular planes which exist between the skin/Dartos and the Dartos/Buck's layers [21].

Corresponding to the arterial supply, the anterior scrotal veins drain into the external pudendal vein before draining into the great saphenous or femoral vein whereas the posterior scrotal veins drain into the dorsal vein of the penis and internal pudendal veins. The testicle drains into the pampiniform plexus, which anatomically can be split into the anterior group, intermediate group, and posterior group [31]. The anterior plexus contains the spermatic vein, which drains the blood from the testis and epididymal head. The intermediate plexus contains the vein of the ductus deferens, and the posterior plexus contains the cremasteric veins. Varicoceles affect 15% of men and 10% of these men experience pain, some of which fail non-operative management

and necessitate surgical treatment of the varicocele [35]. In varicocele surgery, the internal spermatic veins, i.e. those of the anterior plexus, are ligated and sclerosed, thus requiring the posterior plexus/external pudendal vein to take the brunt of the drainage burden [31].

Nervous and lymphatic drainage of the scrotum are relatively simplistic. The pudendal nerve gives rise to posterior scrotal nerves which supply the innervation to the skin/Dartos of the posterior scrotum. The anterior scrotal nerves are derived from the ilioinguinal and genitofemoral nerves after they course through the external inguinal ring [30, 31]. The genitofemoral nerve also supplies the motor fibers responsible for cremasteric contraction, which elevate the testicles and contract the scrotum. Lymphatic drainage of the testicles run alongside the spermatic vessels until they reach the abdominal aortic lymph nodes between the common iliacs and renal vessels. The scrotum and penis drain to the superficial and deep inguinal nodes [31]. Though less important in reconstructive surgery, the distinction between these two lymphatic drainages is very important in oncologic surgery.

37.4 Conclusions

The authors hope that this brief review of surgical anatomy will help the reader have a better understanding of the surgical techniques outlined in the following chapters. Though it may seem as though the external genitalia and perineum are a confluence of rather simple anatomic features, the intricate workings of the anatomic features of the penis, scrotum, and perineum must be appreciated in order to be successful at the time of surgical management.

Key Summary Points

- Anatomical planes must be respected and repaired in sequence throughout the genitourinary system in order to obtain the most optimal outcomes.

- The neurovascular bundle of the penis is located dorsally and should be carefully mobilized during Peyronie's disease corrections.
- When implanting reservoirs for IPP and AUS, the un-violated space of Retzius is preferred; however, care must be given to avoid transecting the external iliac vein.
- Treatment of urethral stricture must also involve treatment of the surrounding spongiofibrosis to decrease recurrence.
- Urethral reconstruction via EPA or grafts offer superior outcomes with respect to long-term ureteral patency over DVIU or balloon dilations.
- Blood supply must always be preserved and respected during dissections. In the case of penile/urethral surgery, bear in mind the dual blood supply and that the retrograde blood flow is lost after hypospadias repairs, AUS implantation, and prior urethroplasties.
- The robust blood supply to the testicle allows it to be substantially debrided and repaired primarily without need for orchiectomy.
- The scrotum's loose nature makes for a very forgiving tissue in terms of reconstructive outcomes; however this makes it prone to development of large hematomas if there is inadequate hemostasis during surgery. We have a low threshold to return to the operating room for evacuation of these hematomas.

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Modern Non-Surgical Treatment Strategies for Peyronie's Disease

38

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38.1 Introduction

Peyronie's disease (PD) is a fibrotic disorder resulting in a scar or "plaque" within the tunica albuginea of the penis. It is estimated to impact up to 9% of the male population, with higher incidences seen in certain populations such as those with prostate cancer where the incidence may be as high as 15% or more [1, 2]. PD is characterized by penile pain, sexual dysfunction, and penile deformity, and it can have a significant impact on quality of life for the patient and his partner [3]. Evidence supports an underlying genetic predisposition to abnormal wound healing in the setting of trauma, possibly through autosomal dominant inheritance with incomplete penetrance [4, 5]. However, the majority of patients do not recall a specific incidence of coital trauma [6–8]. This suggests that sub-clinical or so called "micro-trauma" may trigger a disordered cascade of pro-fibrotic signals within the injured tunica

in the majority of patients [9]. Up and down-regulation of various chemokines and cytokines including transforming growth factor- β 1 and matrix metalloproteinases, among many others, have been implicated in the abnormal fibroblast activity that is thought to result in PD plaque formation [4, 10]. Our understanding of the cellular mechanisms that underlie PD is far from complete. However, attempts to modify the abnormal signaling cascades implicated in PD are the basis for non-surgical treatments including both oral and intralesional injection therapies [11].

Treatment options for PD vary widely and include oral therapies, penile traction, vacuum therapy, intralesional injections, and surgery, which remains the gold standard for correcting penile curvature and other deformities [12]. The treatment choice selected by a patient and his treating physician is based largely on the degree of physical and psychological patient dissatisfaction. Functional limitations from penile deformity, the presence of erectile dysfunction and other sexual dysfunction, and psychological concerns are all factors that contribute to overall dissatisfaction and must be considered during initial evaluation [13]. Another important consideration is the duration of PD and symptom stability. It is helpful to differentiate those patients who are in the B), and Collagenase Clostridium histolyticum (CCH).

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38.2 Natural History of Untreated PD

A discussion of non-surgical treatments for PD would be incomplete without considering the natural history of untreated PD. Observation is ultimately chosen by many patients after carefully considering all options, and should be discussed with patients who present for evaluation. Despite this, the literature in this realm is relatively sparse. One of the earliest reports on untreated PD came from Williams and Thomas in 1970 [14]. They reported a 50% resolution rate in 12 men with untreated PD. However, subsequent studies have not corroborated these early findings. For instance, Gelbard and colleagues assessed a cohort of patients with PD duration ranging from three months to eight years [15]. The authors found that only 13% of patients experienced symptom improvement, while 45% and 42% noted disease stability or progression. Also, Mulhall and colleagues followed a cohort of 246 men presenting in the acute phase of PD who elected observation [16]. With a mean follow-up of 14.5 months, they similarly found that only 12% of patients had objective penile deformity improvement on physical examination compared with disease progression in 48% and stability in the remaining 40%. Pain resolved or significantly improved in the vast majority of patients.

Data regarding long-term patient-centered outcomes in those electing observation is even harder to come by. In their study, Gelbard and colleagues found that patients with a disease duration in excess of four years were more likely to report symptom improvement [15]. More recently, survey results were reported from a cohort of 125 patients with PD who elected conservative management with non-surgical and non-injection therapies [17]. At a median of 8.4 years after diagnosis, nearly 38% of patients noted improvement in their overall disease process. It is important to consider that the differences seen between these studies may reflect, in part, differences in patients' perception of the disease, as those electing long-term observation beyond the acute phase conceivably have less severe disease. For instance, in the previously mentioned study the majority of patients reported

penile curvature of less than 30–45 degrees [17]. Regardless, while sparse, the available data regarding the natural history of untreated PD provide important information for counseling patients regarding observation.

38.3 Oral and Topical Therapy

The evidence for oral PD therapy is sorely lacking, and no oral medications have been shown to reliably benefit patients in rigorous clinical studies. The various agents that have been historically used for PD treatment work via a variety of mechanisms such as reactive oxygen species inactivation and modulation of various pro-inflammatory factors. Their use makes logical sense, but it is felt that most oral medications are unlikely to aggregate in adequate concentration with the PD plaque to exert a meaningful effect secondary to the decreased vascularity within the scarred tunica. In fact, the American Urological Association (AUA) Guideline Panel on PD recommends against the use of oral therapies including vitamin E, tamoxifen, procarbazine, omega-3 fatty acids, and combination vitamin E with L-carnitine due to lack of efficacy [18]. Other agents that have been studied include colchicine, carnitine, and even phosphodiesterase (PDE) 5-inhibitors. Again, no trials have supported their use as monotherapy for PD. [19]

Pentoxifylline (PTX) is a non-specific PDE-inhibitor with anti-fibrotic properties [20]. A 2010 randomized-controlled study of 284 patients treated with PTX versus placebo showed a decrease in the likelihood of PD progression and an improvement in objective penile curvature [21]. However, this study was retracted due to concerns regarding statistical analysis and possible results fabrication. There is animal data that supports anti-fibrotic mechanisms underlying PTX, and due to this potential therapeutic effect, low cost, and the mild side effect profile (most commonly gastrointestinal upset and headache), PTX is recommended by some authorities, particularly in the acute phase [22–24]. PTX may also stabilize or even decrease the degree of plaque calcification [25]. Finally, PTX in combi-

nation with other treatments such as L-arginine (a nitric-oxide synthase stimulator), penile traction therapy, and intralesional verapamil injections has shown promise, particularly in those patients who desire penile length recovery [26].

Topical therapies, most notably verapamil with electromotive drug administrative therapy (EMDA), have been evaluated as well. Verapamil is a calcium-channel blocker that prevents the incorporation of proline, an important component of the extracellular matrix scaffold that allows the Peyronie's plaque to form [27]. Ultimately, this decreases fibroblast proliferation and the quantity of collagen produced and upregulates collagenase activity. EMDA works through the application of an electric field to help achieve higher tissue concentrations. However, to date no studies have shown an objective improvement with topical verapamil +/- EMDA, and this therapy is also recommended against by the AUA PD guideline panel due to lack of efficacy [18]. Recently, results were published from a pilot study involving 22 patients with acute-phase PD who were randomized to receive a novel topical agent known as H-100 gel (nicardipine, superoxide dismutase, and emu oil) versus placebo for three months, followed by a three-month crossover period [28]. The proposed mechanism involves improved tissue penetration as a result of the emu oil. Patients in both the treatment and control arms realized improvements in stretched penile length. The treatment arm demonstrated improvements in curvature and pain, as did those in the control arm after cross-over. These results should be interpreted with caution, and further study is required prior to validation for routine use.

38.4 Penile Traction Therapy and Vacuum Erection Devices

Penile traction therapy (PTT) refers to the application of mechanical forces to the penis through an external stretching device. At the cellular level, the underlying mechanism is known as "mechanotransduction", wherein the applied

forces promote cellular changes including a down-regulation of myofibroblast activity and increased matrix metalloproteinase activity. This results in alterations to the extracellular matrix, which is important for PD plaque remodeling [29]. Several different traction devices are available with various patient-reported advantages and disadvantages associated with each.

There are few studies regarding PTT monotherapy in PD (Table 38.1). In 2008, Levine and colleagues performed a pilot study with ten PD patients who utilized PTT for two to ten hours per day for six months [32]. In this uncontrolled study, objective penile curvature improved by approximately 33% and stretched penile length (SPL) increased by a mean of 1.0 cm (range 0.5–2.0 cm). Subjective and objective girth enhancements in areas of narrowing were also seen. Similarly, in 2009 Gontero and colleagues found that PTT for at least five hours daily over a period of six months resulted in a mean SPL gain of 1.3 cm, although the average penile curvature was not significantly changed [34]. The strongest evidence for PTT as monotherapy comes from Martinez-Salamanca and colleagues [35]. In their non-randomized controlled trial of PTT for a recommended six to nine hours daily in men during the acute phase of PD, they found significant improvements in penile curvature (from 33 degrees at baseline to 15 degrees after six months of PTT) along with improvements in erectile hardness, penile pain, and stretched penile length. They also found that patients had an improved ability for penetrative intercourse, and up to 40% of patients avoided surgery due to their improvements. Penile curvature <45 degrees, time from diagnosis $\leq$ three months, and age < 45 were all predictors of success in their cohort. Notably, on subgroup analysis of those patients with disease duration > three months, no significant improvements were noted.

There is even less data regarding vacuum erection device (VED) therapy in patients with PD. A recent study from Lin and colleagues showed that both PTT and VED improved penile curvature in a PD rat model [36]. In 2010 Raheem and colleagues reported that VED monotherapy (twice daily for 12 weeks) resulted in penile curvature improvements in 21/31 patients (67%), ranging

Table 38.1 Summary of studies evaluating efficacy of penile traction therapy in men with Peyronie's Disease

Study	Year (N)	Mean F/U (mo)	Study design, population	Received use (actual use)	Δ Length (cm)	Δ Circumference (cm)	Δ Curve (°)	Adverse events, other
<i>PTT as primary therapy</i>								
Martinez-Salamanca et al. [24]	2014 (96)	9	Prospective, open label; men with PD in acute phase (progressive curve ± pain in past 12 mo); compared PTT (<i>n</i> = 55) and no PTT (<i>n</i> = 41); mean age = 48–50 y; mean PD duration = 7–8 mo	6–9 h/d × 6 mo (4.6 h/d)	6 mo: PTT +1.5*, no PTT –2.6*	6 mo: PTT +0.9*, no PTT –0.1	6 mo: PTT –18*, no PTT +23*	Erythema 2%; transient pain 25%; no worsening of erections (IIEF); no sensory loss; results maintained at 9 mo: IIEF-6: PTT +6*, no PTT –6*; SEP2: %yes: PTT +27*, no PTT –9*, predictive factors: Age < 45 y, diagnosis <3 mo, curvature <45°, pain >5, absence of plaques
Gontero et al. [25]	2009 [30]	12	Prospective, uncontrolled; men with PD and < 50° curve, >12-mo duration; before vs after tx; mean age = 53 y; mean PD duration = 16 mo	≥5 h/d × 6 mo (5–5.5 h/d)	6 mo: Flaccid +1.3*, stretched +0.8*; 12 mo: Flaccid +1.4*, stretched +1.0*	6 mo: +0.1	6 mo: –4; 12 mo: –4	Ecchymoses 13%; pruritus 7%; plaque size not significantly changed; IIEF score + 0.9 at 12 mo
Levine et al. [26]	2008 [10]	6	Prospective, uncontrolled; men with PD; before vs after tx; mean age = 56 y; mean PD duration = 29 mo; mean curvature = 51°	2–8 h/d × 6 mo (4.5 h/d)	+1	+0.5 to +1.0	–22	IIEF EFD score + 5.3
<i>PTT with ILI therapies</i>								
Ziegelmann et al. [27]	2017 [31]	NA	Retrospective; men with PD undergoing CCH; PTT vs no PTT; mean age = 58 y; mean PD duration = 29 mo	3 h/d (1.2 h/d)	PTT +0.4, no PTT –0.35	NA	PTT –20, no PTT –24	Only 37% used PTT > 3 h/d; no difference in extent of improvement based on PTT use
Yafi et al. [28]	2015 (112)	NA	Retrospective; men with PD; tx with ILI IFN; PTT (<i>n</i> = 34) vs no PTT (<i>n</i> = 78); mean age = 55 y; mean PD duration = 2.9 y	≥2 h/d (NA)	PTT +0.2, no PTT +0.1; PTT ≥ 3 h + 0.4*; PTT < 3 h + 0.1	PTT +0.3, no PTT +0.2	PTT –8, no PTT –10	

Abern et al. [29]	2012 (74)	~1	Prospective; men with PD; tx with ILI of verapamil, L-arginine, pentoxifylline ± PTT; before vs after tx; mean age = 58 y; mean PD duration = 1.1–1.8 y	2–8 h/d (3.3 h/d)	PTT +0.3, no PTT –0.7	NA	PTT –11*, no PTT –15*	No adverse events; 0.38-cm estimated length gain per h/d use
<i>PTT after surgery</i>								
Rybak et al. [32]	2012 (111)	6–10	Retrospective; men with PD men S/P TAP or PEG; PTT vs no PTT; mean age = 53–57 y	2–6 h/d × 3 mo at 3–4 wk. postoperatively (2.4–2.6 h × 5 d/wk. × 3–4 mo)	TAP + PTT +0.6*, TAP + no PTT –0.5, PEG + PTT –0.4*, PEG + no PTT –1.6	NA	NA	Values reported are outcomes after traction vs postoperative, pre-traction values; stretched lengths significant for PTT vs no PTT; perceived length gain 47%–68% with PTT vs 7%–14% without PTT*

CCH collagenase *clostridium histolyticum*, *EFD* erectile function domain, *F/U* follow-up, *IFN* interferon-α2b, *IIEF* International Index of Erectile Function, *ILI* intralesional injection, *NA* not available, *PD* Peyronie's disease, *PEG* partial excision and grafting, *PP* penile prosthesis, *PTT* penile traction therapy, *S/P* status post; *SEP2* Sexual Encounter Profile question 2 ("Were you able to insert your penis into your partner's vagina?"), *TAP* tunica albuginea plication, *Tx* treatment, Δ change

*Statistically significant ($p < 0.05$)

Source: Avant et al. [33]

from 5–25 degrees [37]. Data regarding improvement in penile length with VED are extrapolated from clinical studies in patients undergoing inflatable penile prosthesis (IPP) placement. For instance, Canguven and colleagues found that daily VED use prior to IPP placement resulted in a mean 0.8 cm increase in SPL, suggesting a role for VED in length preservation and/or restoration [38]. Similarly, Tsambarlis and Levine reported a 0.92 cm mean SPL improvement in patients with severe corporal fibrosis who were treated with regular VED prior to IPP placement [39].

In summary, the currently available literature appears to support PTT as monotherapy for PD, with the strongest evidence available for utilization in the acute phase. PTT may have a benefit on penile length, girth, and potentially penile curvature, although further study is warranted. In all published studies to date, the traction device was worn for at least three hours per day, and often in excess of six to eight hours per day, over a period of months to achieve the reported results [26]. Prior to considering treatment, PTT patients must have realistic expectations regarding the commitment necessary to optimize outcomes. Thus, with the currently available devices, PTT should be considered for patients who are willing to commit to a time-intensive treatment option that may provide minor benefits as noted above. Importantly, PTT used in combination with intralesional injections or surgery has also been reported with promising results, particularly with respect to penile length improvements [26]. VED therapy may improve penile curvature and stretched penile length as well, although the data are lacking.

38.5 Intralesional Injection Therapy

Intralesional injection therapy for PD can be considered as an alternative to more conservative therapies such as oral or PTT, which have very little evidence to support significant improvements in PD outcomes, and surgery, which is considered the gold standard for penile straightening but is also associated

with the potential for bothersome side effects. The AUA Guideline for PD states that treatment with intralesional interferon α -2B (INF), verapamil, and Collagenase Clostridium histolyticum (CCH) may be considered [18]. When counseling patients, it is important to discuss expected outcomes. Specifically, the degree of penile curvature improvement with intralesional therapy can be variable, but on average is substantially lower than that seen with surgical straightening. However, intralesional injections have been suggested to prevent the need for penile straightening surgery or “down-grade” the approach from incision/excision with grafting to a “less-invasive” plication [7].

These therapies are likely best utilized for patients who want to avoid surgical intervention with mild to moderate bothersome penile curvature in the absence of severe wasting deformity such as indentation or hourglass that may result in significant penile instability. We will discuss these agents in greater detail including indications for use. We will also describe our technique for intralesional injections. Corticosteroids and other intralesional therapies have also been studied, but given the potential side effects and lack of clinical efficacy, these are not recommended for PD and will not be further discussed [11, 18].

38.6 Interferon α -2B

INF works by inhibiting fibroblast proliferation and increasing collagenase activity, thereby leading to a decrease in collagen within the PD plaque [40]. A multi-center, prospective, parallel controlled trial of 117 patients (mean PD duration 20 months) with non-calcified plaques and curvature >30 degrees who were treated with intralesional INF or placebo showed significant improvements in objectively measured penile curvature (13.5 degrees for INF versus 4.5 degrees for placebo) and penile pain resolution (68% for INF versus 28% for placebo) [41]. Patients treated with INF also had significant improvements in penile hemodynamics including peak systolic velocity and resistive index, although the clinical significance of these find-

ings may be minimal [42]. In contrast, another randomized study of 30 patients treated with INF with or without Vitamin E compared to those treated with Vitamin E alone did not show any significant improvement in penile curvature, although this trial was underpowered and patients had a mean PD duration of only six months [43]. Notably, there was once again a trend identified towards greater improvement in penile pain with INF (70–80% of patients treated with interferon realized improvements, compared with 50% in those treated with Vitamin E alone). Side effects include flu-like symptoms such as arthralgia, fever, and chills as well as penile swelling and bruising, all of which are self-limited and can be mitigated with pre-injection non-steroidal anti-inflammatory use [41, 43]. Based on these results, and those from other observational studies, it appears that INF may provide a quite modest improvement in penile curvature and improve penile pain as well.

38.7 Verapamil

As discussed above, verapamil is a calcium-channel blocker that prevents incorporation of proline into the extracellular matrix of the PD plaque [27]. This results in down-regulation of fibroblast activity and decreased collagen production. To date, the data supporting verapamil is less robust than other intralesional agents. A prospective study of 156 patients treated with intralesional verapamil from Levine and colleagues found that 60% of patients realized an objective curvature improvement with an average decrease of 17 degrees [44]. Sexual function, penile girth, and penile rigidity distal to the plaque also improved in >70% of patients. In contrast, a randomized controlled study by Shirazi and colleagues did not identify a difference in penile curvature changes between patients who received intralesional verapamil and placebo [45]. Importantly, the patient populations in these and other studies varied widely, as did the injection protocols, making inferences less reliable.

Verapamil may improve penile pain as well. In 1997, Levine reported that 28/29 men (97%) with penile pain had complete resolution at a mean of 2.5 verapamil injections, suggesting this as a treatment option for patients with bothersome pain resulting from PD. [46] However, pain improvement was found to be similar between the verapamil and control groups in the study by Shirazi and colleagues [45]. Verapamil in combination with other treatments such as oral therapy and PTT may further optimize outcomes [26]. This agent is generally well-tolerated with minimal side effects including transient bruising, pain, or penile sensitivity, all of which are extremely rare [44–46]. Thus, while the overall benefit is not clear due to weaknesses in the available literature, intralesional verapamil is a safe and well-tolerated treatment option that may be considered for patients with PD.

38.8 Collagenase Clostridium Histolyticum

CCH or *Xiaflex* (Endo; Dublin, Ireland) is the only United States Federal Drug Administration (FDA) approved treatment for PD. The collagenase is derived from the bacterial organism *C. histolyticum* which selectively degrades type II and III collagen fibers of the PD plaque [47]. Clostridial collagenases have been studied for over three decades, but it was not until the landmark IMPRESS I and IMPRESS II randomized, double-blinded, placebo-controlled trials that we had definitive level I evidence for CCH in the treatment of PD. [48] Combined data from these two studies revealed a mean 17 degree (34%) improvement in penile curvature for the CCH group, compared with nine degrees (18%) in the placebo. The authors also found a significant improvement in the patient bother domain of the Peyronie's Disease Questionnaire, a validated instrument for assessing outcomes with PD. [49] This ultimately led to FDA approval in December, 2013. Patients included in the IMPRESS trials had dorsal, lateral, or dorsolateral penile curvature between 30 and 90 degrees, and 79% had a curvature <60 degrees. Notable exclusion criteria included ventral penile

curvature and severe plaque calcification, among others, and the mean PD duration was nearly four years PD. [48] Currently, CCH is indicated for adult men with PD who have a palpable plaque and penile deformity with curvature of at least 30 degrees at the start of therapy.

For the most part, post-approval studies support findings from the randomized trials and demonstrated its role in the urologist's armamentarium. One notable publication reported a less-encouraging non-statistically significant mean improvement of five degrees with CCH, and the underlying reason for these results is not clear [7, 31, 50–53]. Several studies have also evaluated predictors of CCH-success. Sub-group analyses from the IMPRESS trials suggested that patients with less severe curve (<60 degrees), longer disease duration, non-calcified plaques, and stronger baseline erectile function had significantly greater reductions in penile deformity [54]. Moderate calcification (with shadowing) and several calcifications in excess of 1 cm in greatest dimension may also predict poor response [55]. The IMPRESS trials included patients in the chronic phase, but recent work has shown that patients in the acute phase may achieve similar degrees of objective curve improvement as well [53].

Currently, CCH administration techniques vary, although investigators in the IMPRESS trial followed a standardized protocol [48]. Initial evaluation included assessment of the penis for palpable plaques followed by curvature assessment of the erect penis after intracavernosal injection (ICI) of an erectogenic medication such as prostaglandin E1 or trimix. The point of maximum curvature (POMC) was measured. A treatment cycle consisted of two CCH injections (0.58 mg), separated by 24–72 hours. The medication was injected directly into the plaque at the POMC. Approximately 24–72 hours after the second injection, manual modeling was performed by the physician in the office. This cycle was repeated for a total of 4 series, followed by a final curvature assessment. Variations on the original technique include the amount of drug administered (0.9 mg), volume of instillation, whether or not an artificial erection is induced with each injection, adjunctive use of traction or vacuum therapy, and self-administered modeling, among others. For

instance, Abdel Raheem and colleagues evaluated a shortened protocol, wherein a single injection of 0.9 mg of CCH (the entire vial) is administered once every four weeks for a total of three cycles [56]. When coupled with home modeling and daily vacuum erection device therapy, the authors reported outcomes similar to the original protocol, with a mean improvement of 17 degrees (34%).

The potential side effects with CCH must be discussed with patients prior to starting this therapy. Specifically, common side effects include penile ecchymosis (>80%), transient edema (>50%), and pain (>45%) [48, 57]. More severe complications include penile hematoma and corporal rupture, which may require surgical repair in some instances [58]. Post-injection penile wraps and avoidance of sexual activity for two to four weeks may help to minimize these risks [7, 58]. Additional long-term research is needed to define the optimal treatment protocol and compare outcomes against historical therapies.

38.8.1 Combination Therapy

Combination therapy with PTT or VED and intralesional injections or surgery to optimize outcomes should be considered, although once again the literature is limited. Abern and colleagues studied PTT used concurrently with L-arginine, Pentoxifylline, and intralesional verapamil. PTT for a mean 3.3 hours/day resulted in non-statistically significant increases in stretched penile length of 0.3 cm compared with a loss of 0.7 cm in a comparison group of patients who did not use PTT, and the duration of PTT seemed to predict greater stretched penile length improvements [26]. However, there was no significant difference in penile curvature improvement between those who did and did not utilize PTT. Similarly, Yafi and colleagues compared patients undergoing INF injections who did and did not utilize PTT [59]. They too found no significant differences in penile curvature improvement between the two groups, but did identify that patients who utilized PTT for at least three hours daily had significantly greater improvements in penile length. Finally, results from 51 patients treated with CCH, including 35 who utilized PTT, again

showed no significant differences in penile curvature based on PTT utilization, although there was a trend towards increased stretched penile length in those who utilized PTT (+0.4 cm vs -0.35 cm) [60]. Importantly, despite significant counseling efforts, patient compliance with PTT recommendations was poor, with <10% utilizing PTT for the recommended $\geq$ three hours/day.

Key Points

- Various non-surgical options are available for PD treatment.
- The data for oral and topical therapies is lacking, and to date no strong evidence exists to support their efficacy in human patients.
- Intralesional injections with interferon α -2B, verapamil, and CCH may improve penile curvature.
- Based on phase three data from the IMPRESS 1 and 2 trials, CCH is the only FDA-approved non-surgical treatment option for PD

38.9 Injection Techniques

38.9.1 Verapamil and Interferon α -2B

Here, we will discuss Dr. Laurence Levine's protocol and technique for verapamil injections in a penile plaque located on the dorsum of the penis. A similar technique can be utilized for INF as well. A total of 10 mg of verapamil is recommended with each injection. A 5 mg vial of verapamil typically contains 2 ml solution, so an additional 6 ml of injectable saline is required to reach a final volume of 10 ml.

A preparatory solution is used to clean the penis, and a dorsal penile block or penile ring block is then performed. We utilize 10 ml of 0.5% bupivacaine. The anesthetic is administered through a 27-gauge needle. We allow at least 10–15 minutes for the anesthetic to set in, and longer is better when it comes to local anesthesia. During this time the verapamil solution is

drawn up in a 10-ml luer-lock syringe. We use a 25 gauge 5/8-inch needle to administer the agent as we have found this to decrease the risk for needle fracture, minimize patient discomfort, and efficiently distribute the agent into the tissues. The plaque is isolated between the thumb and forefinger of the non-dominant hand. (Fig. 38.1a) The needle is then placed through the skin directly into the plaque coming in from the lateral aspect of the dorsum of the penis. The goal with this approach is to skive under the neurovascular bundle, thereby avoiding any theoretical injury to the sensory nerves and superficial vessels (hematoma). Multiple passes are made through the plaque as the medication is gently administered. The goal is to distribute the medication throughout the plaque without grossly disrupting or destroying the plaque from the force of the injection. This allows the medication to exert its greatest effect locally on the underlying tissues. If the plaque grossly involves the septum, it may be necessary to puncture the skin a second time in a more vertical manner. Of note, ventral plaques are quite difficult to isolate and target, and intralesional injections in this area pose a theoretical risk to the underlying urethra. As such, we do not routinely treat ventral plaques with intralesional verapamil, although others have described minor success for ventral curvature. Also, in those plaques found to be severely calcified ("plate"-like) on penile ultrasound, intralesional injections are unlikely to provide much benefit as the medication cannot be adequately administered to the underlying tissue.

Once the entire 10 cc has been administered, the patient is instructed to apply pressure to the penis for approximately five to ten minutes to minimize ecchymosis and prevent hematoma formation. Side effects are self-limited and include penile ecchymosis and temporary pain at the injection site. In general, we recommend that patients initially undergo six cycles of verapamil injections. Each cycle involves one injection, and the cycles are administered at least two weeks apart (although in our experience extending this to three or even four weeks does not significantly change treatment efficacy). If symptom improvement is realized, additional cycles may be considered. Moreover, if there are no significant side

effects, the dose may be increased to 20 mg (four 2-cc verapamil vials mixed with 2-cc of injectable saline) [61].

38.9.2 Collagenase Clostridium Histolyticum

As noted above, several modifications to the CCH protocol described in the IMPRESS I and II trials have been described. Here, we will discuss Dr. Landon Trost's protocol and injection technique using the full 0.9 mg dose (off-label). Complete CCH preparation is beyond the scope of this chapter, and the reader is referred to the manufacturer's website for full details and information on the risk evaluation and mitigation strategies (REMS) training program. Briefly, CCH includes two vials – one with the lyophilized CCH powder and the second with a diluent that contains calcium which is necessary to activate the CCH. The two vials are refrigerated until just prior to administration. They should remain at room temperature for at least 15 minutes. The full volume of diluent (0.39 mL) is mixed with the lyophilized CCH powder. Next, the full volume (equivalent to 0.9 mg) of the active medication is withdrawn into a syringe with a 27-gauge needle. This reconstituted CCH solution can be kept at room temperature for up to one-hour, or refrigerated for up to four hours.

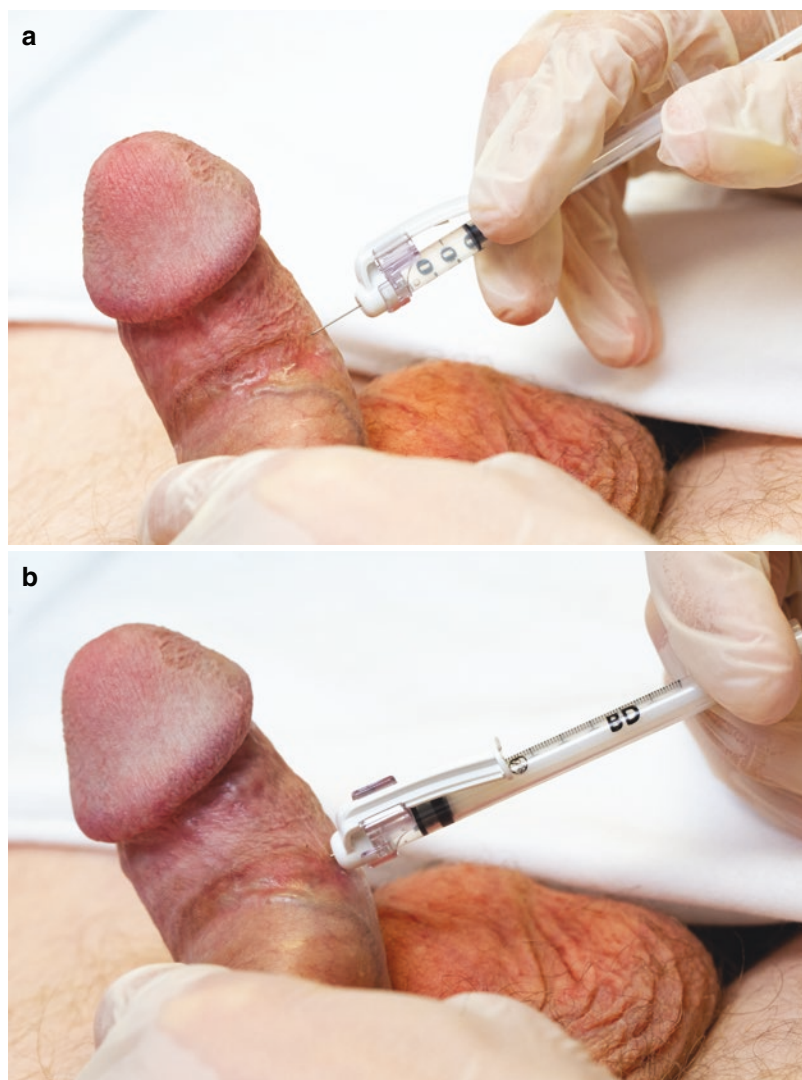
We recommend that an artificial erection be performed prior to each injection with an erectogenic agent such as prostaglandin E1 or trimix. (Fig. 38.1) This allows for the most accurate identification of the point of maximal curvature and was an early change to the injection practice, as it was quickly recognized that the point of maximal curvature could migrate as much as 1–7 cm from the original location over the course of treatment. Once the point of maximum curvature (POMC) has been identified, the previously prepared CCH is injected directly into the plaque at the level of the POMC. (Fig. 38.2a, b) It is important to note that significant resistance is often met as the CCH is injected directly into the plaque, and this may be associated with patient discomfort. The resistance serves as direct and immediate feedback – verifying appropriate location for drug administration. If resistance is not met, we advocate that the needle be re-positioned. This can be subtle and great care is required to prevent administration of this very small quantity of medication into the wrong location, thus negating any potential benefits.

Once the entire 0.39 mL is administered, the needle is withdrawn. If necessary, intracavernosal phenylephrine can be administered to promote detumescence. The penis is then wrapped with a compressive gauze dressing. (Fig. 38.3) Care is taken to avoid placing the wrap too tight as this may theoretically impact urination secondary to urethral compression. We recommend

Fig. 38.1 A goniometer is used to perform penile curvature assessment



Fig. 38.2 The CCH is administered within the PD plaque (a)—identifying resistance and patient discomfort are two helpful cues that suggest appropriate needle placement for medication administration (b)



that the penile wrap be continued for at least 24 hours post-injection to minimize ecchymosis and hematoma formation. A second injection is then performed in a similar manner 24–72 hours later. As with the first injection, an artificial erection is again induced, and the injection placed into the tunical plaque at the point of maximal curvature. Following the second injection, we recommend that the patient continue to wrap the penis for the next three to five days after the injection to minimize the risk of hematoma formation. Specifically, the wrap should be worn when showering and changed immediately thereafter, as this is a common time for developing hematoma secondary to vasodilation. A total of four series of two injections (eight total

injections) are recommended unless the patient experiences satisfactory outcomes prior to that point, with at least six weeks in between injection cycles. While some patients may elect to discontinue therapy after two injection series, we have found that most patients realize subsequent improvements in penile curvature with additional CCH cycles, even in the absence of early success [62]. We do not routinely recommend additional series, as our preliminary data did not demonstrate additional improvements beyond four series in the majority of men. In contrast to the IMPRESS protocol, we routinely instruct patients to avoid any sexual activity for at least four weeks after each series in order to minimize the risk for corporal rupture.



Fig. 38.3 A penile wrap is applied with compressive gauze after CCH injection to minimize risk for bruising and hematoma. The wrap is maintained for 24 hours

Ecchymosis is nearly universal after CCH injections, and hematomas are also commonly encountered. On rare occasions, patients may experience suspected minor penile fractures with a “popping” sensation, detumescence, and rapid onset of penile swelling and bruising. Most often, these occur with spontaneous erections and not during penetrative intercourse. In contrast to the more traditional corporal rupture, we recommend against surgical repair if the patient is able to achieve a subsequent erection, and our preliminary data suggests possible greater curvature improvements in those patients with a suspected minor rupture who were observed without surgery compared with a parallel series of men without suspected ruptures. On the other hand, if the patient has a history and examination consistent with penile fracture and is unable to achieve an erection, penile exploration with corporal repair and possible concurrent penile straightening is indicated.

Arguably the most important aspect of the protocol is modeling, which must occur following injection. In the original phase IIb CCH clinical trial, men who did not undergo modeling demonstrated no improvements compared to controls [63]. In our practice, we recommend aggressive self-modeling for 30 seconds straight out and

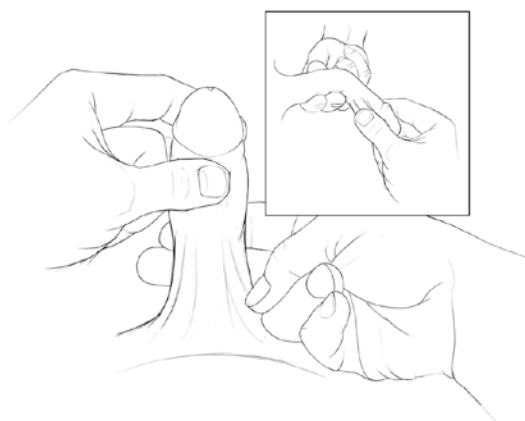


Fig. 38.4 The patient is instructed to perform daily manual modeling by holding the penis straight out from the body on stretch for a total of 30 seconds. The penis should then be stretched in the direction opposite the curve for an additional 30 seconds. This should be performed multiple times per day

again in the opposite direction of the curvature. This has to be done with every void throughout the day beginning on the day of the injection and continuing until six weeks following the final injection of the series. (Fig. 38.4) We also recommend adjunctive PTT beginning on the day of the injection (or as soon as tolerated) and continuing until six weeks after the final injection.

38.10 Conclusions

PD is a relatively common condition resulting in penile pain, deformity, and sexual dysfunction. It can have a significant impact on patient and partner well-being. Surgery remains the gold standard for correcting bothersome penile curvature or other deformity that prevents satisfactory sexual intercourse. However, a variety of non-surgical options are available for the appropriately selected patient or for the man who wants to avoid surgery. There is no strong evidence for oral or topical therapy in PD. Penile traction and vacuum erection devices may help to improve or maintain length, and also may improve penile deformity in the acute phase. Finally, intraleisional injections including verapamil, interferon α -2B, and Collagenase *Clostridium histolyticum* (the only FDA-approved treatment for PD) can improve penile curvature and/or pain. These agents may prevent surgery or potentially allow a less-invasive surgery (tunica plication rather than plaque incision/excision with grafting) to be performed.

Key Summary Points

- Intraleisional verapamil (10 mg in 10 mL of injectable normal saline) is administered into the Peyronie's plaque through a multi-puncture technique with a 25 gauge 5/8-inch needle, grasping the plaque with the thumb and forefinger. A penile ring block is performed prior to injection. Six-cycles of one injection every two weeks is recommended as starting therapy, but additional cycles can be performed.
- Intraleisional collagenase clostridium histolyticum is administered directly into the plaque with a single injection (0.9 mg in 0.39 mL of diluent). Prior to each injection, an artificial erection should be performed to identify the point of maximum curvature, which can migrate during the course of treatment. A penile wrap and avoidance of

sexual activity for at least four weeks after the injection cycle are important to minimize the risk of hematoma and corporal rupture. A total of four injection series, each consisting of two injections separated by 24–72 hours, along with manual modeling and penile traction may be performed.

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Modern Plication Strategies for Surgical Correction of Peyronie's Disease

39

Alexander K. Chow and Laurence A. Levine

39.1 Indications

Tunica albuginea plication (TAP) for the treatment of Peyronie's disease is indicated for penile curvatures less than 70 degrees in the absence of hinging or advanced narrowing, and/or when potential further penile shortening is tolerable to the patient. TAP is also indicated in patients with curvatures greater than 70° with co-existing mild erectile dysfunction as plaque excision and grafting does have an increased risk of erectile dysfunction [2, 4–8]. The surgical goal with TAP is to correct the penile curvature to functional straightness which is defined by expert opinion as curvature <20° [2, 3].

39.2 General Principles

The principle of TAP is to identify the point of maximal curvature (PoMC) on the penile shaft and to shorten the opposing or convex aspect of the tunica albuginea to match the length of the contralateral side. The greater the curvature, the greater the shortening is needed on the convex side therefore TAP is best considered for mild to moderate curvature (<70°) and if compromising

penile length is not unacceptable to the patient and/or their partner. This point is critical when discussing surgical options with patients and selecting cases for TAP preoperatively as 70–80% of patients already have loss of penile length from the PD due to the loss of tunica elasticity from the fibrotic disease process [1, 2, 9].

The advantages of penile shortening procedures when compared to penile lengthening procedures is that it is a relatively easier surgery with shorter operative time, which can offer straightening with a lower risk of postoperative erectile function for the properly selected patients [5, 10]. The critical disadvantage to plication procedures is the penile shortening which occurs on the convex side by definition but also the inability to correct “indentation” deformities which can result in an unstable erection due to hinging.

39.3 Excision Technique

Penile straightening by plication was first described by Nesbit in 1965. It was introduced as a surgical technique to correct congenital ventral chordee [11, 12]. This procedure involved an elliptical excision of the tunica albuginea on the convex side of the curvature. After the small wedge of tunica was excised, the elliptical tunical edges were approximated using permanent sutures [12]. (Fig. 39.1) Reports of this early technique have shown correc-

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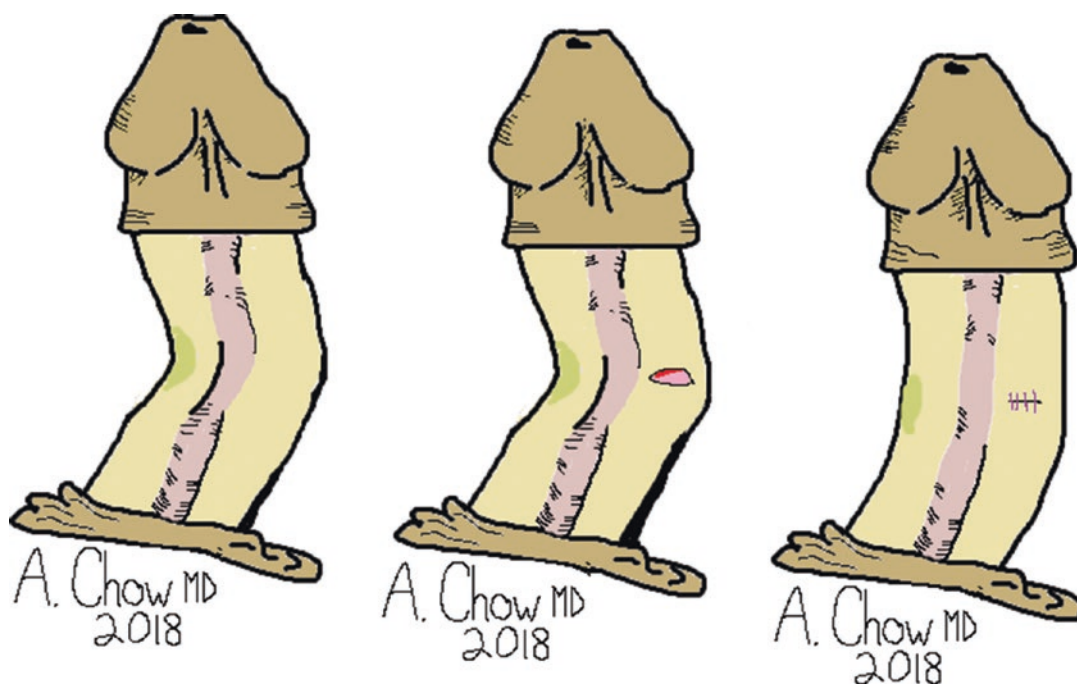


Fig. 39.1 Nesbit technique

tion of penile curvature in 91% and preservation of erectile function in 82–89% [13, 14].

39.4 Incision Technique

Several decades later, Yachia introduced the Heineke-Mikulitz technique to correct penile curvature [15]. This technique differs from the Nesbit procedure in that the tunica is incised rather than excised. Full thickness vertical incision(s) measuring 0.5–1.5 cm in length is made on the tunica opposing the (PoMC). The vertical incisions are then closed transversely which will shorten the convex side and reduces the angulation of the erect penis. (Fig. 39.2) Minimizing the length of the vertical full thickness incision of the tunica albuginea is crucial, as transverse closure of the tunica edges of long incisions can create or exacerbate pre-existing narrowing of the penile shaft which may result in an unstable erection. Published series on this technique have showed a high number of patients reporting penile functional straightness (92–93%) [16–18].

39.5 Partial Thickness Incision Techniques

The technique that we routinely utilize at our institution is the modified Duckett-Baskin technique which was initially developed for correction of congenital curvature in children [19, 20]. This is a partial tunical incising technique that removes the outer longitudinal tunica fibers but preserves the inner circular fibers. We favor this technique as leaving the internal tunica fibers intact obviates the violation of the internal cavernosal erectile tissue, which should help preserve the patient's penile rigidity. Removal of the external tunical fibers also debulks the plicated tunica, making the plication site less bulky. Permanent suture 2–0 Tevdek (Teleflex Medical, Research Triangle Park, NC) is placed in an inverted vertical mattress fashion to bury the knot. The primary approximation of the transverse incisions with Tevdek is re-enforced with one or more 3–0 PDS sutures placed in a Lembert fashion. This will also help to bury the Tevdek knot. This technique will be described in detail later in the *Author's Step-by-Step Operative Guide* portion of the chapter (Fig. 39.3).

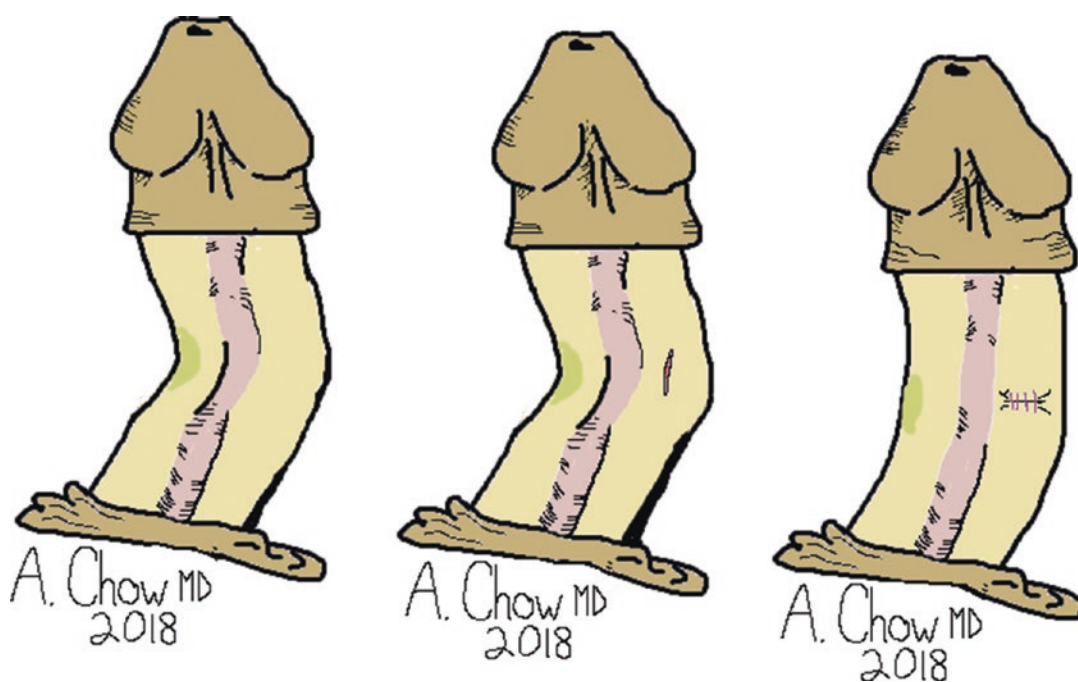


Fig. 39.2 Heineke-Mikulitz technique

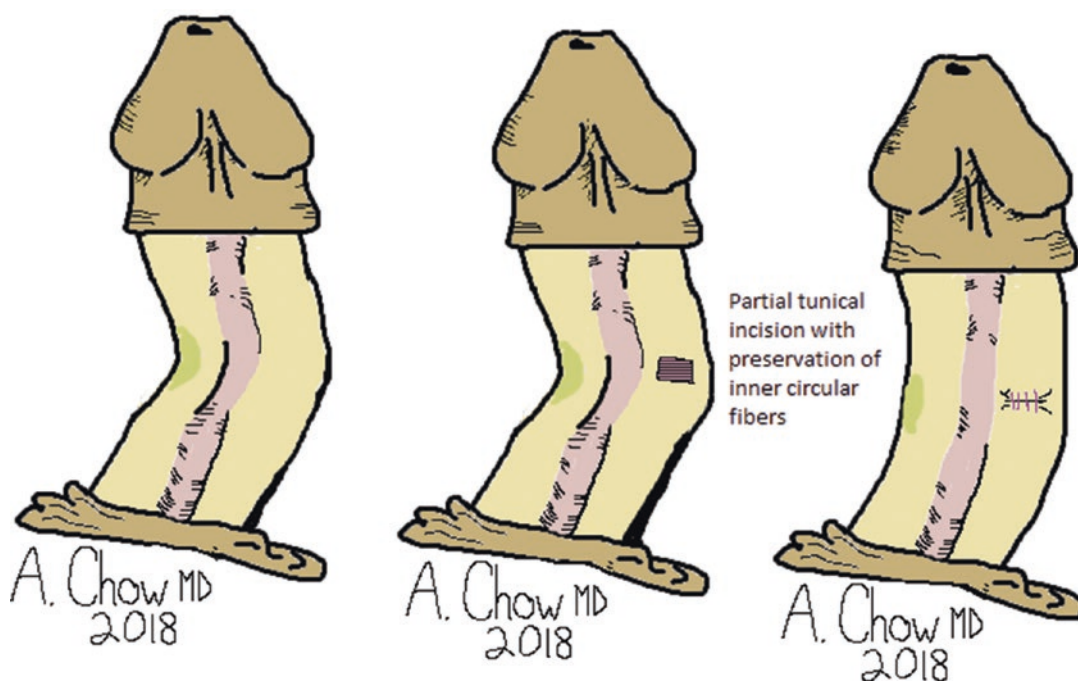


Fig. 39.3 Modified Duckett-Baskin technique

39.6 Incisionless Imbrication Techniques

Imbrication procedures are used as an alternative to avoid full-thickness incision of the tunica. The incisionless technique conceivably preserves erectile function by leaving the tunica intact. Limiting the potential compromise to penile rigidity is important as up to a third of men with PD already have some degree of erectile dysfunction [21]. Essed and Schroeder published the first series using incisionless plication in five men with Peyronie's disease, all treated with imbrication using non-absorbable sutures in a figure-of-eight pattern [22]. Ebbehøj used a similar method of plication to correct congenital penile curvature [23]. The incisionless imbrication procedure was further popularized by the 16-dot technique often referred to as the Lue procedure [24–26]. This penile shortening technique involved two extended parallel suture lines of Lambert-type plication utilizing permanent sutures (Fig. 39.4).

Several modifications of the 16-dot techniques have emerged recently. Osama Schaeer introduced a new method of imbrication known as the Double-Eight Plication technique. Standard plication suture lines are taken parallel to the outer longitu-

dinal fibers of the tunica albuginea which the authors point out may be prone to tearing with erection and resulting in recurrent curvature [26]. The Double-Eight plication technique follows the concept of the 16-dot plication but each figure-of-eight plication is placed in crisscrossing pattern which secures the tunica fibers in an interlocking manner reducing the likelihood of recurrence due to the sutures tearing through the tunica. The authors saw no recurrence in a series of 60 patients at an average follow-up of three years [26].

The Kiel Knots plication is another modification of the 16-dot plication that was created to make the plication knots less apparent and to improve the patient's comfort level [27, 28]. The gaps between the plication sutures are closely spaced (about 5 mm apart) when compared to the original 16 dot plication technique in an effort to minimize relevance of the longer suture to maintain straightness. A thin superficial transverse slit about 5 mm long is made at the location of planned plication without violating the underlying corpora cavernosa. Each of these slits act as a trough for the knot to lay in and to be buried once the suture is tied down. (Fig. 39.5) Patients undergoing this method report less bothersome penile sensations associated with suture knots [28].

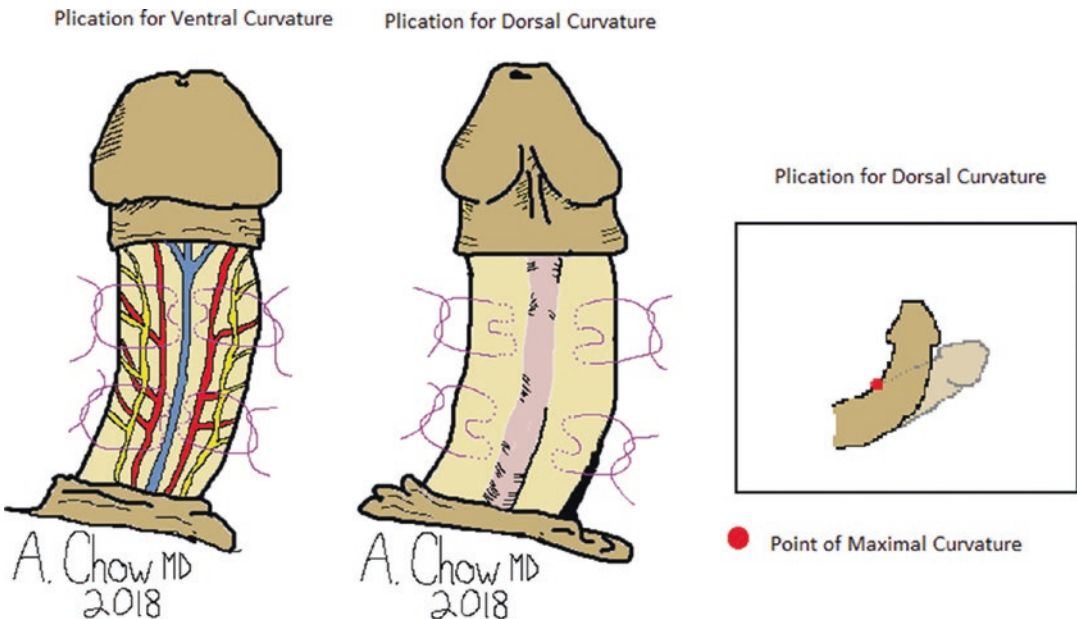


Fig. 39.4 16-dot plication techniques

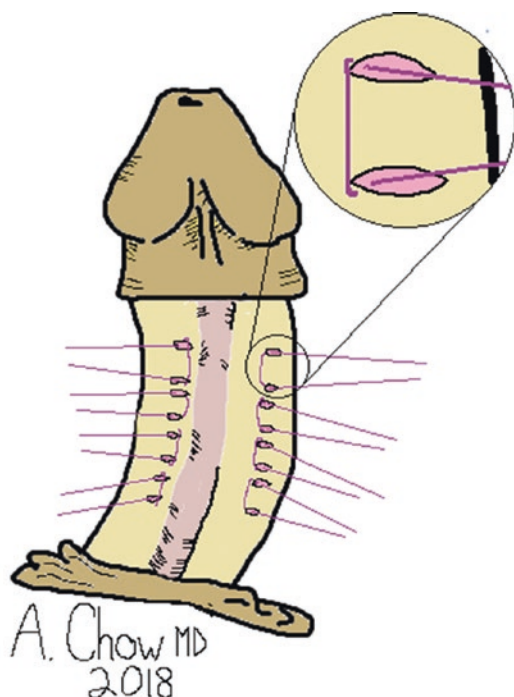


Fig. 39.5 Kiel knots procedure

39.7 Minimally Invasive Technique

Morey et al. introduced the penoscrotal plication which omits the need for a circumscribing incision and degloving of the penis [28]. Here, a longitudinal incision measuring 2–3 cm is made at the mid to proximal shaft opposing the PoMC. After dividing and mobilizing the underlying dartos, Senn retractors allow for exposure and dissection of the dartos. This can be done in the desired direction if needed to virtually expose any portion of the penile shaft [28]. Multiple plications utilizing non-absorbable 2–0 ethibond sutures are placed in an inverted mattress fashion along the opposing side of the PoMC. Multiple series of plications, up to 21 in their reported experience, can be performed to achieve functional straightness ($<20^\circ$). These authors encourage the use of this “minimally invasive” technique for a wide span of men with PD ranging from mild to severe curvatures with complex multiplanar deformities [29].

39.8 Improving Patient Comfort

One of the drawbacks of all plication procedures is the potential to have palpable knots which can create pain, discomfort and/or sexual displeasure to the patient [2]. Several modified techniques as previously discussed have been created to improve patient comfort. The partial depth incision technique excises the longitudinal fibers between the transverse incisions to reduce the bulk of the plication [19, 20]. Knots can be inverted and buried in the inscribed trough as described in the Kiel Knots procedure [27]. We also advocate for limiting permanent sutures to reduce the incidence of bothersome suture nodules. A review of our experience with mostly non-permanent sutures in 142 men who underwent TAP found durable correction of curvature with a low incidence of bothersome nodularity (4.9%) as compared to historically reported bothersome nodules in 39% when all permanent sutures were used [30].

39.9 TAP as a Supplemental Procedure

TAP can be utilized as a supplemental procedure for men with severe compound curvature who undergo a grafting procedure. PD with compound curvature occurs when an elongated plaque or multiple plaques involve an extended area of the penile shaft. When grafting is used as the primary therapy in this situation, correction of the PoMC alone may leave behind residual curvature. At our institution, we utilize TAP as described later, to address the residual curvature. The authors published a recent series evaluating men with severe compound curvature. TAP was employed as a supplemental technique to optimize straightening and did not compromise post-operative penile length, result in diminished penile sensitivity, or reduced rigidity when compared to men treated with grafting alone [31].

39.10 Comment on Penile Shortening

Greenfield et al. found that the direction of curvature, (particularly ventral and ventrolateral deviation, degree of primary curvature at time of

surgery, particularly when $>70^\circ$) predicted the likelihood of bothersome shortening. Number of plications, plaque size, and presence of narrowing did not seem to affect loss of penile length [32]. Therefore, men with ventral curvature greater than 70° have the greatest potential for penile length loss with plication procedures and should be counseled on this risk before proceeding with this approach particularly if penile length loss is a concern.

Regardless of the technique used, the role of plication is to make the penis “functionally straight” as defined as residual deformity less than 20° [2, 3]. Overall reports on plication regardless of technique have shown functional straightness achieved in 85–100% of patients with patient satisfaction ranging from 70–100% and a low rate of de novo erectile dysfunction in 0–13% of those who undergo the procedure [3].

39.11 Author's Step-by-Step Operative Guide

Prior to induction of general anesthesia, we typically administer weight dosed intravenous first generation cephalosporin or alternatively Clindamycin based on the American Urological Association guidelines for open urological surgery [33]. The patient is positioned in the supine position and after administration of general anesthesia, the lower abdomen, genitalia, and perineum is shaved, prepped and draped.

The stretched flaccid penile length (SPL) is first measured dorsally from the pubis bone to the corona with the penis on full stretch perpendicular to the body. We find this penile measuring method to be reliable as both anatomical locations of the pubis and corona represent two fixed points which allows for repeatable and accurate measurements.

A 21-gauge butterfly needle is inserted through one side of the glans lateral to the meatus into the distal corpus cavernosal tissue. An artificial erection is then induced with injection of a vasoactive agent such as 20 mcg alprostadil (Caverject, Pfizer, New York City, NY, USA) followed by hydro distension with instillation of

sterile injectable saline. The erect penis is then evaluated by measuring curvature with a goniometer as well as identifying other penile deformities including indentation, narrowing, hinging or hourglass deformity. The PoMC is identified.

A circumferential circumcising incision is made 1.5–2 cm proximal to the corona down to Buck's fascia. The penis is then degloved which allows for exposure of Buck's fascia along the entire length of the shaft. Degloving the penis is best achieved by using a Ray-tec sponge and applying firm and gradual pressure on the dartos and penile skin and pushing it towards the base of the penis. Hemostasis using fine bipolar electrocautery is achieved as necessary. The PoMC is identified and the penile curvature is measured with a goniometer once again. In the case of a dorsal curvature, the convex side of the PoMC is then inspected to determine the optimal location for the first plication, which will likely be on one or both sides of the urethra. Buck's fascia is elevated by making a longitudinal incision, approximately 1 cm lateral to the urethra allowing elevation of Buck's fascia to the urethral ridge of the tunica medially and laterally so as to expose the ventral-lateral aspect of the tunica.

At this point, there are numerous techniques for plication as discussed above with the preferred method left to the discretion of the operating surgeon. At our institution, we routinely perform the modified Duckett-Baskin technique [19, 20]. After Buck's fascia is elevated, two parallel transverse incisions are made through the outer longitudinal fibers of the tunica albuginea. The incisions can range from 0.5 to 1.5 cm in length and approximately 0.4–1.0 cm apart depending on the degree of desired shortening. Once the longitudinal fibers are incised, the tissue between the incisions is shaved out with a #15 blade leaving the underlying inner circular fibers of the tunica intact. This technique is favored as it reduces the redundant tunical tissue that is plicated but it also preserves the inner circular fibers for penile support, reducing the likelihood of postoperative erectile dysfunction. The two transverse incisions are then approximated particularly in the PoMC area with a single permanent suture (2–0 Tevdek) in an inverted verti-

cal mattress fashion and reinforced as needed in Lembert fashion using absorbable 3–0 polydioxanone suture. Following each plication, the erect penis is re-examined to assess for residual curvature. Additional plications are placed as necessary to gain optimal straightening. We have found that the most distal plications can be performed without permanent suture. Morey quoted that up to 21 plications may be necessary to achieve straightening [28]. In our experience, one to six separate plications may be needed to achieve straightness when a TAP is performed alone or in concert with a grafting operation [30]. Buck's fascia is reapproximated with running 4–0 chromic (Ethicon, Belgium). The dartos of the penile shaft is then reapproximated with interrupted 4–0 monocril (Ethicon, Belgium) and the circumscripting skin incision is closed with interrupted 4–0 chromic in a horizontal mattress fashion. The postoperative dressing is important to reduce bleeding and swelling. We apply a Xeroform (Medline Industries Inc., Northfield IL) Vaseline gauze bandage (1 × 8 inches) followed by a lightly applied Coban (3 M, Maplewood, MI) wrap starting distally at the corona and moving to the base. The dressing is meant to stay on the penis for three days.

39.12 Postoperative Care

The patient is typically seen two weeks after surgery for a post-operative evaluation and to initiate penile rehabilitation. He is instructed to start manual stretching and massaging the penis to preserve elasticity and reduce tissue contraction. The patient is instructed to grasp the penis by the glans and gently pull it away from the body while the other hand massages the shaft. We recommend patients to perform this routine for five minutes twice a day for up to four weeks. We strongly encourage initiation of external penile traction therapy three to four weeks post-operatively for at least two to three hours daily for three months [34]. We prefer the Peni-Master Pro (MSP Concept, Berlin) device as it applies no compression to the shaft or glans. At six weeks post-operatively if the wound is healed and the

patient is pain-free he may resume penetrative sexual activity.

39.13 Conclusion

Penile shortening techniques have evolved since its conception as an excisional procedure (Nesbit) to include variations of full and partial thickness incision as well as no-incision imbrication techniques. No comparative trials exist to demonstrate that any one plication technique is superior to the others. Penile plication is indicated for the man with mild to moderate curvature ($<70^\circ$ without significant narrowing or hinging) and can offer functional straightness ($<20^\circ$) for the properly selected patient.

Key Summary Points

- Penile shortening techniques have evolved since its conception as an excisional procedure (Nesbit) to include variations of full and partial thickness incision as well as no-incision imbrication techniques.
- Penile plication is indicated for the man with mild to moderate curvature ($<70^\circ$ without significant narrowing or hinging) and can offer functional straightness ($<20^\circ$) for the properly selected patient.
- Plication procedures may exacerbate indentation or hinge-effect and therefore may not be the optimal approach when significant narrowing is present.
- There have not been any comparative trials to demonstrate that any one plication technique is superior to the others.
- Modern modification of plication techniques focus on improving patient comfort by making the suture knot less palpable by inverting it and the use of fewer permanent sutures without evidence of increased risk of recurrent curvature.

- Plication can be used as a supplemental procedure to a grafting procedure to correct residual curvature without evidence of added loss of penile length, decreased penile sensation or erectile dysfunction compared to men treated with PEG alone.
- Post-plication rehabilitation is essential for obtaining optimal surgical results.

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Modern Strategies for Grafting in Peyronie's Disease

40

Georgios Hatzichristodoulou

40.1 Introduction

Peyronie's disease (PD) is a benign fibrotic disorder that leads to inelastic plaque formation within the tunica albuginea of the penis [1, 2]. The prevalence of the disease is estimated to be 3–9% of the male population. Peyronie's disease occurs mainly in men between 40 and 70 years of age [1, 3–6]. Symptoms of the disease include penile plaques, penile curvature, penile deformities (such as hourglass deformity), penile shortening, painful erections, erectile dysfunction (ED), and psychological distress [1, 7, 8]. The most bothersome and most important symptom in the majority of patients is penile curvature, as this can lead to the inability to perform sexual intercourse [1, 2].

Conservative treatment options are usually used in the acute phase of PD in order to reduce penile pain and prevent further progression of the disease. These include oral medications, intralesional injection therapy and mechanical therapies like penile traction or extracorporeal shock wave therapy [1, 2, 9–12].

Surgical therapy of PD still represents the gold standard to correct penile curvature. This can be divided in three main procedures: (1) plication

techniques, (2) grafting techniques following partial plaque excision/incision, and (3) correction of penile curvature with simultaneous penile prosthesis implantation in patients with PD and ED not responding to conservative/medical therapy [7, 13–15].

This chapter is focused on grafting techniques for surgical reconstruction of PD. Special attention is paid on modern grafting techniques and novel grafting materials. Additionally, this chapter offers a detailed step-by-step tutorial for grafting techniques in PD. Moreover, indications for surgery, patient counselling, pre- and postoperative considerations, and postoperative rehabilitation protocols are discussed.

40.2 Surgical Therapy

Surgery represents the gold standard treatment to correct penile curvature in patients with PD. Indications for surgical therapy of PD include disease duration >12 months, stable disease >6 months, pain-freedom, and most importantly the inability to perform satisfying sexual intercourse due to the extent of penile curvature [14, 15]. Table 40.1 lists indications for surgical therapy of PD. The three main surgical procedures in PD are listed above. Plication techniques lead to penile straightening by shortening the convex side of curvature (e.g. Nesbit procedure, 16-dot technique, and modifications). These tech-

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Table 40.1 Indications for surgical therapy of Peyronie’s disease

Disease duration at least 12 months
Stable disease at least 6 months
Penile curvature making sexual intercourse impossible
Absence of penile pain
Patient is well-informed and has realistic expectations

niques can be applied in penile curvatures $<60^\circ$, and when the patient displays an adequate penile length [1]. Penile prosthesis implantation with simultaneous correction of penile curvature is indicated when patients with PD simultaneously suffer from ED that is not responding to medical and conservative treatment options. The residual curvature which often persist, even after placement of the implant cylinders, can be addressed by either the modeling maneuver, plication or grafting [16–18].

40.2.1 Perioperative Evaluation

Due to lack of pathophysiological knowledge, there is currently no healing of PD. This means that all treatment options available today are symptomatic treatments, which of course also applies to surgical treatment. Surgery should only be offered in the stable phase of the disease in order to minimize the risk of recurrence or progression. According to the literature, recurrent curvature can occur in 10–33% of cases [19, 20]. Counselling of the patient prior to surgery is important, as there are risks and side effects associated with any surgical intervention. The patient should moreover provide an informed signed consent. It is also very important that realistic expectations are being set and that the patient understands that there are limitations to any surgical intervention. In this regard it is crucial to mention that the penis will never become as it was before the onset of the disease (length, shape, size) because PD leads to some irreversible changes of the penis. According to recent literature, the severity of penile curvature is the main limiting factor for sexual intercourse, especially when curvature is $>60^\circ$, rather than other

penile deformities like the hourglass deformity [21]. Penile shortening can occur with any surgical procedure, though the risk of shortening is less with grafting techniques [22]. This is important, as most patients will report some penile shortening already occurring since the onset of their PD [23]. Another adverse effect can be persistent penile curvature after surgery. The risk of de-novo ED after surgery can be as high as 67% [24]. As up to 58% of patients with PD are suffering from ED simultaneously, this should be considered accordingly [23]. Penile hypoesthesia or glans numbness can occur in up to 31% of cases [13, 25, 26]. This should also be discussed with the patient.

40.3 Grafting Techniques

Grafting techniques are indicated in more severe penile curvatures $\geq 60^\circ$, in presence of an hourglass deformity or a short penis. However, the patient is required to have sufficient and documented erectile rigidity prior to surgery as the risk of postoperative worsening of erectile function is higher compared to plication. This is because grafting techniques lead to a tunical defect after plaque incision or partial plaque excision and thus, discontinuation of the integrity of the tunica albuginea, which might negatively influence erectile function. Indications for grafting techniques are listed in Table 40.2. Grafting techniques are able to maintain or even restore penile length as the penile shaft is stretched following plaque incision or partial plaque excision at the point of maximum curvature on the concave side of curvature. This means that the tension that exists on the concave side of curvature is removed leading to straightening and

Table 40.2 Indications for grafting techniques in Peyronie’s surgery

Penile curvature $\geq 60^\circ$
Presence of hourglass deformity
Patient has short penis
Sufficient and documented preoperative erectile rigidity/function

stretching of the penile shaft [23]. Complete and extensive plaque removal, as was performed many years ago, is not recommended any more because of the unacceptable high rates of post-operative ED [27].

40.3.1 Surgical Procedure

At the beginning of the procedure an artificial erection test is performed in order to plan the surgical approach. Grafting techniques then start with a circumcising skin incision. In order to prevent chronic lymphedema and wound healing disorders of the prepuce it is recommended to perform a complete circumcision. This should be discussed with the patient in advance. Then penile degloving is performed meaning the preparation of the penile skin down to the base of the penis. This allows exposure of the entire penile shaft. Other techniques, which involve a simple incision of the penile shaft dorsally or ventrally lead to limited exposure and thus are performed less frequently. In the next step, Buck's fascia is opened next to the urethra on both sides and the neurovascular bundle is mobilized. In case of ventral curvatures, a complete mobilization of the neurovascular bundle is not necessary in most

cases. However, in case of lateral curvatures, the respective side of the neurovascular bundle should be dissected in order to allow for incision/partial plaque excision at this site. Then, another artificial erection is performed in order to identify the point of maximum curvature, and to re-assess the degree of curvature as this can sometimes change after mobilization of the neurovascular bundle compared to the initial finding. Then, plaque incision or partial plaque excision is performed at the point of maximum curvature on the concave side of the curvature (which is most often the dorsal aspect of the penis, as dorsal curvatures are most common). Plaque incision can be done by either a transverse incision or a H- or double-Y incision, especially in patients displaying an hourglass deformity (Figs. 40.1, 40.2, and 40.3) [7, 28, 29]. When using grafts other than the collagen fleece, which is described below, the defect of the tunica albuginea should be rectangular to allow for appropriate graft tailoring. Partial plaque excision is usually performed by excising an ellipsoid part of the tunica albuginea at the point of maximum curvature, with the resulting defect (Fig. 40.4) [1, 7, 13, 30, 31]. Attention has to be paid not to damage the underlying cavernous tissue, as this could result in postoperative ED. The resulting tunical defect is then

Fig. 40.1 Transverse plaque incision: incision lines followed by grafting. (Source: From Hatzichristodoulou et al. [7]; Publisher: Elsevier Inc., permission granted)

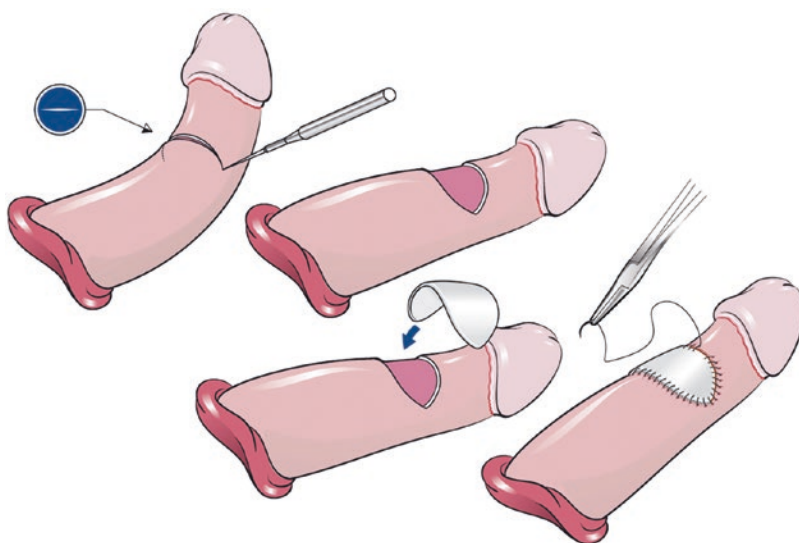


Fig. 40.2 H-incision of plaque in hourglass deformity: incision lines followed by grafting. (Source: From Hatzichristodoulou et al. [7]; Publisher: Elsevier Inc., permission granted)

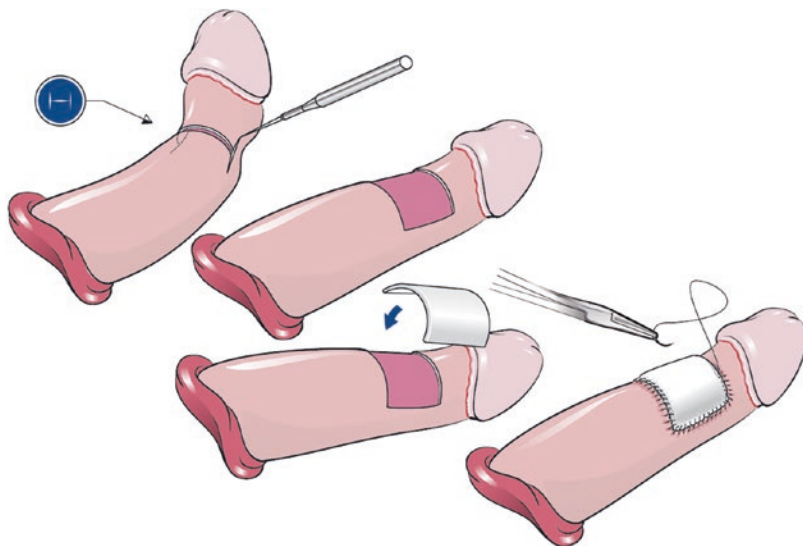
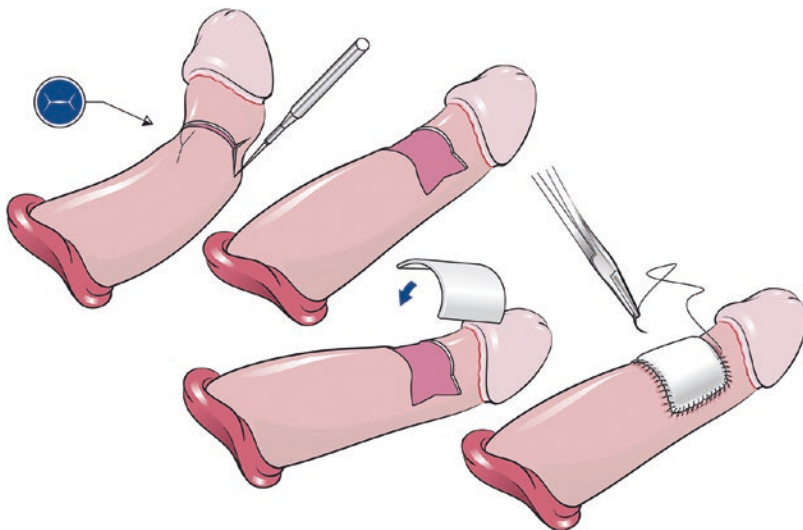


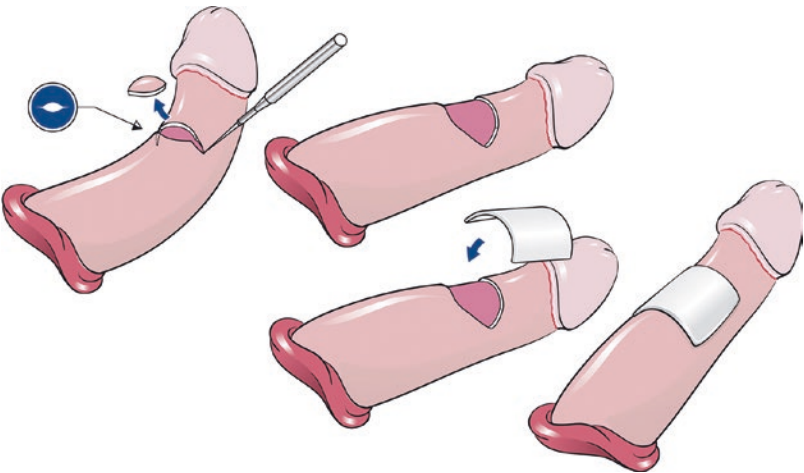
Fig. 40.3 Double Y-incision of plaque in hourglass deformity: incision lines followed by grafting. (Source: From Hatzichristodoulou et al. [7]; Publisher: Elsevier Inc., permission granted)



closed by a graft in order to restore the integrity of the tunica and the penis. There are various autologous and non-autologous grafts available (see below). The graft of choice has to be sewn into the tunical defect, except if the collagen fleece (see below) is used as graft which does

not require suture fixation [13, 30]. Artificial erection is repeated to confirm a watertight closure and adequate correction of the curvature. Sometimes, additional plication sutures need to be placed at this point if residual curvature persists. However, if this is $<15^\circ$ this is usually

Fig. 40.4 Partial plaque excision (Sealing technique): ellipsoid partial plaque excision and further incision lines laterally, followed by closure (sealing) of tunical defect with collagen fleece. (Source: From Hatzichristodoulou et al. [7]; Publisher: Elsevier Inc., permission granted)



regarded as complete correction without the need for additional maneuvers. Buck’s fascia is closed on both sides next to the urethra, and the circumcision is closed [32]. In case of ventral curvature, additional mobilization of the urethra is indicated. In this case, plaque incision or partial plaque excision is performed at the point of maximum curvature on the ventral aspect of the penis beneath the urethra. Defect closure is performed as described above in cases with dorsal penile curvatures. After correction, the urethra is reapproximated and Buck’s fascia is closed [33].

Table 40.3 Autologous and non-autologous grafts for Peyronie’s reconstructive surgery

<i>Tissue-engineered grafts (Xenografts)</i>	Collagen fleece Pericardium Small intestinal submucosa
<i>Autologous grafts</i>	Dermis/ skin Vein Tunica albuginea Tunica vaginalis Buccal/lingual mucosa Fascia lata
<i>Non-autologous grafts</i>	Pericardium Fascia lata Dermis/ skin Dura mater

40.4 Grafting Materials

Grafting techniques lead to a tunical defect after plaque incision or partial plaque excision. This defect has to be closed in order to restore the integrity of the tunica albuginea and the whole penis. There are various autologous and non-autologous grafts available that can be used for this purpose, which are listed in Table 40.3 [13, 24, 25, 27, 31, 34–42]. Nowadays, autologous and non-autologous grafting materials are being

used widely, whereas synthetic grafts are not recommended any more because of risks associated with its use, such as infection, inflammatory response, fibrosis, allergic reaction, and subsequent contracture leading to recurrent penile curvature [31, 43]. Autologous grafts have to be harvested from the patient’s body, which lead to increased operative times and might also lead to increased morbidity [40]. Thus, there is a current trend to use non-autologous “off-the-shelf” grafts

(tissue-engineered materials) like collagen fleece, pericardium, or small intestinal submucosa (SIS) [13, 31]. The ideal graft for PD surgery has not yet been defined. Ideal graft properties should include widely availability, resistance to infection, promotion of haemostasis, and preservation of erectile function. Moreover, it should not contract and be cost-effective. Off-the-shelf grafts should also be available and packaged in various sizes to fit the individual tunical defect. Among all the grafts available, the collagen fleece, pericardium and SIS seem to be the most popular and most frequently used. There are only few data from well-designed comparative studies to determine the ideal graft. As a proper attempt, currently there was the first matched-pair analysis published on this topic comparing SIS vs. collagen fleece in patients with PD undergoing a grafting technique [44]. This study showed that despite similar results in regard to penile straightening and preservation of erectile function, the collagen fleece was superior with respect to preservation of penile length. Moreover, recurrent penile curvature was observed only in the SIS-group, and not in the collagen fleece group, which shows that the risk of contracture of the collagen fleece is less compared with SIS. Additional, the operative time was significantly shorter when using the collagen fleece, as this graft has self-adhesive properties and thus does not require suture fixation.

40.5 Modern Grafting Strategies and Novel Grafts

In recent years, there were a lot of studies published examining and reporting results after grafting techniques in PD using a variety of grafts. In the following, the most interesting and most promising approaches and graft materials will be presented and discussed.

In a study including 63 patients, Hatzichristodoulou et al. reported on their early experience with a novel collagen fleece (TachoSil®, Baxter Healthcare Corporation, CA, USA) as a promising and new graft material for PD surgery [13]. This surgical technique

was introduced as the Sealing Technique [45]. This graft has self-adhesive properties and does not require suture fixation into the tunical defect following plaque incision or partial plaque excision. The graft is moistened with physiological saline and then put on the tunical defect with the graft overlapping the defect of at least 5 mm, in order to stick on the tunica albuginea and provide a watertight closure (Figs. 40.5, 40.6, 40.7, and 40.8) [30]. An exact measurement and placement of the collagen fleece into the tunical defect, as performed with other grafts, is not required. Thus, operative times are reduced. The collagen fleece also provides some advantages over other grafts such as haemostatic effects, easy handling and application, and cost-effectiveness. Mean operative time in this study was 94 min. Totally straightness of the penis was achieved in 83% of cases. The remaining showed a $<10^\circ$ residual curvature, which did not influence sexual intercourse. Ninety-two percentage of patients had normal glans sensation after surgery.

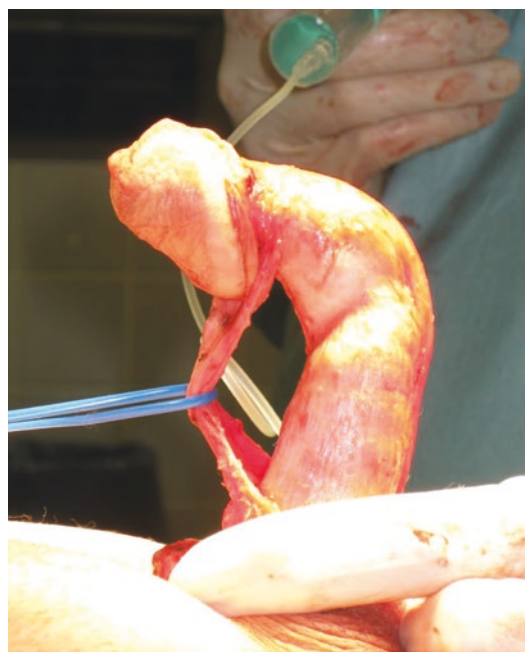


Fig. 40.5 Penile curvature 90° dorsal after mobilization of neurovascular bundle, in artificial erection. (Source: From Hatzichristodoulou et al. [13]; Publisher: Nature Publishing Group)



Fig. 40.6 Tunica albuginea defect after partial plaque excision. (Source: From Hatzichristodoulou et al. [13]; Publisher: Nature Publishing Group)



Fig. 40.7 Closure (sealing) of tunical defect with collagen fleece. (Source: From Hatzichristodoulou et al. [13]; Publisher: Nature Publishing Group)

In summary, the TachoSil® offers two distinct advantages when compared to traditional grafts: (1) It avoids the arduous process of having to sew the carefully prepared and oversized graft into the tunical defect. (2) It generally does not need additional plication sutures as the surgeon can generously incise the Peyronie's plaque in any configuration (the defect does not have to be in a perfect rectangular shape), as long as a margin of normal tunica (at least 5 mm) remains for the TachoSil® to adhere to.

Recently, Hatzichristodoulou also reported on the surgical treatment of ventral penile



Fig. 40.8 Complete straight penis after closure of Buck's fascia, in artificial erection. (Source: From Hatzichristodoulou et al. [13]; Publisher: Nature Publishing Group)

curvatures in PD using this collagen fleece. This technique was introduced as the Ventral Sealing Technique [33]. This technique requires the mobilization of the urethra after opening of Buck's fascia. A plaque incision or partial plaque excision is performed at the point of maximum curvature on the ventral aspect of the penis beneath the urethra. Complete neurovascular bundle mobilization is not regularly required in these cases, except for severe ventral curvatures with co-existing severe hinge effect, hourglass deformity or narrowing. However, partial mobilization of the neurovascular bundle on both sides should be performed in order to provide some space for the collagen fleece to overlap the tunical defect after plaque incision/partial plaque excision. Then, the defect is closed using the collagen fleece (Figs. 40.9, 40.10, 40.11, and 40.12). In this first study using the TachoSil® for ventral grafting, 12 patients with severe ventral curvature were included (mean curvature angle 98.3°, range: 60–150°). 83.3% of patients



Fig. 40.9 Penile curvature 120° ventral after mobilization of neurovascular bundle and urethra, in artificial erection. (Source: From Hatzichristodoulou [33]; Publisher: Springer Nature)



Fig. 40.10 Partial plaque excision at two inflexion points ventrally beneath urethra. (Source: From Hatzichristodoulou [33]; Publisher: Springer Nature)

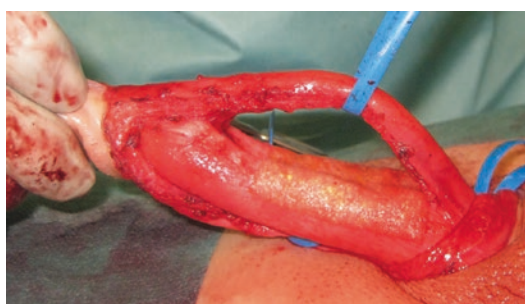


Fig. 40.11 Closure (sealing) of tunical defects ventrally with collagen fleece. (Source: From Hatzichristodoulou [33]; Publisher: Springer Nature)

showed a totally straight penis. The remaining had a residual curvature of $<25^\circ$, which did not interfere with the ability to perform satisfying sexual intercourse. Considering the preopera-



Fig. 40.12 Straight penis after closure of Buck's fascia. (Source: From Hatzichristodoulou [33]; Publisher: Springer Nature)

tive severe ventral penile curvature, results of this study can be regarded as excellent. 91.7% of patients were satisfied with the result of surgery in this study. This first report shows that the collagen fleece can be used successfully as graft in PD surgery, not only for dorsal/dorsolateral but also for ventral penile curvatures.

The novel collagen fleece was also used by Fabiani et al. for repair of patch bulging and cystic dilatation after previous graft surgery using an acellular graft material (Xenform® patch, Boston Scientific, Natick, MA, USA) [46]. The authors made a revision surgery, removed the dilated segment and replaced it with the above-mentioned TachoSil®. This case supports the use of this novel graft not only for primary surgical interventions in PD, but also for revision surgery.

There is one comparative study available today, comparing the SIS graft vs. the collagen fleece during grafting techniques in PD surgery in patients with preserved erectile function [44]. This study showed superior results of the collagen fleece regarding the preservation of penile length and decreased risk of recurrent penile curvatures. Moreover, operative times were significantly shorter when using the collagen fleece, which is related to the self-adhesive properties of the fleece without the need for fixation.

Hatzichristodoulou also introduced the PICS Technique which uses the collagen fleece for tunical defect closure after plaque incision for correction of residual curvature during inflatable penile prosthesis placement in patients with PD and concomitant ED (Figs. 40.13, 40.14, 40.15, and 40.16) [18]. This novel approach addresses residual curvature after placing the implant cylinders by combining the above-described Sealing



Fig. 40.13 Residual penile curvature dorsally, after insertion and inflation of implant cylinders and mobilization of neurovascular bundle. (Source: From Hatzichristodoulou [18]; Publisher: Elsevier Inc., permission granted)



Fig. 40.14 Defect of tunica albuginea after plaque incision at point of maximum curvature (implant cylinders visible). (Source: From Hatzichristodoulou [18]; Publisher: Elsevier Inc., permission granted)

Technique with penile prosthesis implantation [47]. When using other grafts for defect closure after plaque incision with the implant already in the cavernous bodies, there is the risk of device puncture, as other grafts have to be sewn into the defect. This would result in replacing the cylinders, which is a costly issue. As the collagen fleece has self-adhesive properties it sticks on the tunical defect and therefore does not require suture fixation. Thus, there is absolutely no risk of device



Fig. 40.15 Closure (sealing) of tunical defect with collagen fleece. (Source: From Hatzichristodoulou [18]; Publisher: Elsevier Inc., permission granted)



Fig. 40.16 Complete straight penis after closure of Buck's fascia, implant cylinders inflated maximally. (Source: From Hatzichristodoulou [18]; Publisher: Elsevier Inc., permission granted)

damage. In the series by Hatzichristodoulou, 15 patients with a mean residual curvature of 66.7° (range: $50\text{--}90^\circ$) after penile prosthesis placement were included [18]. Totally straightness of the penis was achieved in 80% of cases. The remaining showed a residual curvature of 10° at follow-up, which did not interfere with sexual intercourse. All patients were satisfied with the surgical result.

Falcone et al. reported results of their study comparing two different grafts for defect closure after plaque incision for residual curvature correction during penile prosthesis implantation [17]. They compared the SIS graft vs. the colla-

gen fleece in a group of 60 patients that underwent penile prosthesis implantation and displayed a residual curvature after inserting the implant cylinders. While the surgical and functional results were similar in the two treatment groups, the authors found that the mean operative time was significantly shorter in the collagen fleece group (120 min for the collagen fleece vs. 145 min for the SIS group). Moreover, the authors discussed the costs of these two grafts and concluded that the collagen fleece is more cost-effective. Given the other advantages of the collagen fleece, as mentioned above, it does represent an effec-

tive solution for grafting after penile prosthesis implantation.

In another study, the SIS graft was used in 43 patients with PD with preserved erectile function undergoing a grafting technique after plaque incision [48]. Complete penile straightening of the penis was achieved in 74.4% in this study. 88.4% of patients were able to engage in sexual intercourse (67.4% without aid, 21% with medical help). SIS grafting showed to be a safe approach in this series. However, the operative time has to be considered, as the SIS graft requires suture fixation in a running fashion into the tunica albuginea defect, which is time-consuming. In a similar study by Valente et al. the SIS graft was used in 28 patients with PD [49]. Mean operative time in this study was 151 min, which is longer than with other grafts. Complete penile straightening was observed in 82% of cases. 36% of patients reported ED postoperatively, with 82% of all patients being satisfied with the procedure.

Romero Otero et al. reported on their experience with bovine pericardium for PD grafting surgery in 43 patients [39]. The pericardial graft was sewn in the tunical defect with an absorbable filament after complete plaque excision. Penile straightening rate was as high as 80% in their series. Seventy-five percentage of cases were able to perform sexual intercourse. The ED rate was as high as 25%, requiring further treatment to achieve satisfying erections. Patient satisfaction rate was as high as 85% in this series. In this study, complete plaque excision was performed, which nowadays is not recommended any more. The authors might have improved their outcomes by using a simple plaque incision or partial plaque excision.

Long-term results after grafting techniques in PD are also very promising as shown in a study by Wimpissinger et al. [41]. The authors included 30 patients who underwent plaque incision and vein grafting with either great saphenous vein or dorsal penile vein and reported on their 10-year follow-up. Complete penile straightening was present in 86% of patients in the long-term which represents a very good result. While 36% of patients were suffering from ED, 83% of cases were still able to have sexual intercourse, with or without medical help. Results of this study show that grafting

techniques in PD lead to reliable and satisfactory long-term surgical outcomes, even after a 10-year period.

Another graft type, which has been investigated for PD grafting techniques in recent years is buccal/ lingual mucosa. Zucchi et al. reported on their technique and results using buccal mucosa as potential graft in 32 patients [42]. Complete penile straightening was achieved in 96% of all patients, which does represent a very good result. Only 4% of patients were complaining of postoperative ED. Patient satisfaction rate was as high as 85%. Salem et al. used lingual mucosa as graft in 17 patients undergoing a grafting procedure for PD [40]. Complete penile straightening in this series was achieved in 88% of all patients, which is also a good outcome. Postoperative ED was present in only 6% of patients and patient satisfaction rate was as high as 94% of patients. Despite the fact that this is a very small series, early results show promising results with this type of graft. Mean operative time in this series was 130 min. The prolonged operative times of these procedures represent disadvantages compared to off-the-self grafts as reported above. This is related to the fact that buccal or lingual mucosa grafts have to be harvested from the patient's body. This can also lead to increased morbidity on the donor site, such as discomfort, swelling, numbness, wound-healing disorders and pain.

40.6 Rehabilitation After Grafting Techniques

In the postoperative period, it is recommended that sexual activity and sexual intercourse should start no earlier than 6 weeks after surgery [24, 25, 30]. Penile rehabilitation after grafting techniques is an important issue and seems to help and support the postoperative period and wound healing. This includes massaging and manual stretching of the penis for 30 min daily, beginning 3 weeks after surgery. This should be continued for a time period of 3 months. In order to support penile vascularization and nocturnal erections, phosphodiesterase-type 5 inhibitors (PDE-5i) have been recommended. PDE-5i can

be started 2 weeks after surgery, and given for a period of at least 4 weeks. There are also other similar rehabilitation protocols available with the same purpose. No one protocol has yet emerged as superior [30, 50]. The rehabilitation protocol aims to reduce the risk of ED following surgery, and also reduce the risk of penile shortening postoperatively. Moreover, it should help in recovery of erectile function after surgery, and support penile straightening [19, 23, 31–33]. Penile traction devices, such as the Andropenis (Andromedical, Madrid, Spain) have also been recommended to reduce the risk of penile shortening after surgery. This should be applied for 2–8 hr daily, beginning two weeks after surgery for a period of 3 months [19]. Moreover, penile vacuum devices (pumps) can also be used and recommended for the same purpose.

40.7 Conclusions

Grafting techniques in PD still represent the recommended surgical treatment in patients with penile curvature $>60^\circ$, short penis or with an hourglass deformity. However, patients should have adequate and documented erectile function preoperatively. The patient should be counselled before surgery about possible adverse events and risks associated with the specific surgical approach. Grafting techniques can be challenging and demanding. Thus, these procedures should only be performed by experienced surgeons in the field. In terms of grafting materials, the ideal graft has not been defined. Literature supports the use of off-the-shelf grafts in PD reconstructive surgery. Among all the grafts available today, the novel self-adhesive collagen fleece has emerged as a very promising, effective, and reliable graft which offers some advantages such as (1) self-adhesive properties, (2) stretching capacity, (3) virtually no risk of infection, and (4) easy handling and application. However, surgeon experience, patient selection, and type of penile deformity will affect the choice of graft. As this is a field of growing interest, it remains exciting how surgical techniques and outcomes will develop in the future.

Key Summary Points

- Surgical therapy of Peyronie's disease still represents the gold standard to correct penile curvature.
- Grafting techniques are indicated when curvature is $\geq 60^\circ$, when there is an hourglass deformity or hinge effect and when there is presence of a short penis.
- Grafting techniques can maintain penile length as these procedures lead to penile stretching after plaque incision or partial plaque excision.
- Various autologous and non-autologous grafts can be used to close the defect of the tunica albuginea. However, today non-autologous off-the-shelf grafts are being used predominantly.
- The novel self-adhesive collagen fleece TachoSil® represents a very promising graft as it provides some advantages compared to traditional grafts.
- Surgeon experience, patient selection, and type of penile deformity will affect the choice of graft.
- During the surgical procedure, the anatomy of the penis has to be respected in order to achieve good outcomes and to reduce the risk of complications. This applies especially to the neurovascular bundle, the urethra and the erectile tissue within the corpora cavernosa.
- Appropriate patient selection and adequate patient counselling before surgery is mandatory in order to set realistic expectations and to increase patient satisfaction rates.
- Postoperative penile rehabilitation is recommended in order to reduce the risk of erectile dysfunction and penile shortening postoperatively. Moreover, it can support penile straightening following surgery.

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Modern Strategies for Treatment of Peyronie's Disease with Penile Prosthesis

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41.1 Introduction

Peyronie's Disease (PD) is characterized by robust scar tissue deposition within the tunica albuginea of the penis, presumably in response to penile trauma [1]. The disease affects nearly 10% of men, and even more in certain sub-populations such as those with a history of radical prostatectomy [2]. While the presentation is highly variable, common symptoms include penile pain, penile deformity, and sexual dysfunction, often resulting in severe psychological bother for the patient and his partner [3]. Multiple treatment options are available for PD, and a full review is beyond the scope of the current chapter. For an in-depth discussion of non-surgical management including intralesional injections, readers are referred to Chap. 38 ("Modern Non-Surgical Treatment for Peyronie's Disease"). To date, surgery is the gold standard for correcting penile curvature and other deformity [4]. Surgical

straightening with out a penile prosthesis should be reserved for patients in the chronic or "stable" phase of the disease process. The true definition of the "stable-phase" is ill-defined, but we consider symptom duration of at least 12 months and stable deformity for ≥ 3 –6 months as a reasonable standard in most cases [5].

41.2 Peyronie's Disease and Erectile Dysfunction: Patient Evaluation and Treatment Selection

Comorbid erectile dysfunction (ED) is common and is present in 30–45% of PD patients [6, 7]. Shared risk factors include diabetes, smoking, obesity, hypertension, and hyperlipidemia [8]. Some feel that underlying ED predisposes patients to penile trauma with intercourse resulting in PD. Alternatively, it has been suggested that underlying changes to the structural integrity of the tunica albuginea in PD predispose to venous leak. However, various authors have found that both veno-occlusive dysfunction and arterial insufficiency are both common in patients with PD [9, 10]. Moreover, the link between penile deformity severity and vasculogenic ED is unclear with some studies supporting this relationship and others refuting it [9, 11, 12]. Thus,

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the etiology for the high co-occurrence between ED and PD is likely multifactorial due in part to the shared risk factors for both conditions, but also to the underlying pathophysiology of PD and the structural alterations to the erectile tissues of the penis.

Regardless of the underlying etiology, this finding has important implications in the treatment algorithm for PD, particularly in those patients with more complex deformity (see further discussion below) where surgical management is recommended [13]. This is because surgical straightening procedures such as grafting and even penile plication are associated with de novo ED in up to 30% of patients [14]. In their retrospective review of over 200 men who underwent surgical straightening without an inflatable penile prosthesis (IPP) for PD, Levine and colleagues failed to identify any preoperative risk factors or objective findings on penile duplex Doppler ultrasound that were associated with a higher risk for postoperative ED with both plication and grafting procedures without IPP [14]. In contrast, Flores and colleagues found that the presence of venous leak on penile ultrasound, increased age, and greater penile curvature were independent risk factors for a ≥ 6 -point drop in the international index of erectile function (IIEF) questionnaire after plaque incision and grafting [15].

Preoperative erectile function assessment is thus imperative during the initial consultation and with subsequent follow-up (Table 41.1). Erection status may be assessed using objective measures such as the IIEF or Erection hardness score, or more subjective patient-reported measures such as a Lichert-type scale from 0 to 10 (where 0 is no erection and 7 is barely firm enough for penetrative intercourse, or some other variation as defined by the evaluating physician). Current and prior treatments for ED such as oral phosphodiesterase-5 inhibitor (PDE5I) therapy or intracavernosal injections of erectogenic medications including dosages should be elicited as well. Another helpful hint is to simply ask the patient: “If your penis were straight, would you be able to have satisfactory penetrative sex with your current erections?” or some variation of this question [13].

Table 41.1 Important components of the initial history, physical examination, and additional testing for Peyronie’s Disease

History	
	Pain
	Scar tissue
	Curvature
	Indentation, narrowing
	Penile shortening
	Penile instability
	Erectile function (IIEF ^a , EHS ^b , Lichert-scale)
	Peyronie’s Disease Questionnaire
Physical Examination	
	Genitalia (inguinal region, testes)
	Penile plaque, elasticity
	Stretched penile length
Additional Testing	
	Penile ultrasound
	Curvature assessment (with ICI ^c)
	+/- Biothesiometry

^aInternational Index of Erectile Function

^bErection Hardness Score

^cIntracavernosal injection

In those patients with chronic phase PD who desire surgical management, the treatment of choice depends on patient bother, severity of the penile deformity, and baseline sexual function. By definition, the degree of patient bother is a subjective outcome. Studies have shown that greater deformity results in more severe bother, but we have all encountered the patient with minimal penile curvature who has severe psychological distress impacting multiple facets of his life as well as the patient with severe penile curvature and destabilizing hinge effect preventing penetrative intercourse who has very minimal distress [16]. In patients with minimal bother, observation or non-invasive treatments such as traction or intralesional injections are excellent options. In patients with severe bother despite mild deformity demanding invasive treatment that is not indicated, referral for psychologic counseling should be considered [3].

Objective penile deformity can be broadly broken down into “mild to moderate” and “severe” deformities. While surgery is the most reliable way to restore a functionally straight penis, non-surgical therapies are often considered for patients with “mild to moderate” deformity (<60° without

severe destabilizing indentation). For instance, collagenase clostridium histolyticum (Xiaflex®; Endo, Dublin, Ireland) is an intralesional injection therapy approved to treat dorsal and dorso-lateral penile curvature between 30 and 90° [17]. In contrast, more severe deformities often require surgical intervention. In these circumstances, baseline erectile function can help identify those patients who are better candidates for IPP rather than straightening alone.

In their review of outcomes with a surgical treatment algorithm, Levine and colleagues defined severe PD deformity as curvature >60° and/or indentation or hourglass deformity resulting in a severe destabilizing hinge effect when axial force was applied to the erect penis [13]. In patients with milder deformities, tunica plication was performed. For those with severe deformity, the more complex grafting procedures (as opposed to plication) were offered to patients without ED or with ED that was responsive to PDE5I therapy. For any deformity and poor response to PDE5Is, penile prosthesis with adjunctive straightening maneuvers as necessary was performed. Utilizing these criteria, >88% of patients were able to engage in sexual activity postoperatively.

Similarly, Mulhall and colleagues reported results from their surgical algorithm for patients with PD and concurrent ED [18]. They offered surgical straightening without penile prosthesis, including corporoplasty (plication) for the less severe and grafting for the more severe cases, only to those patients without ED or with adequate response to PDE5I therapy. In all others, penile prosthesis with adjunctive straightening as needed was performed. The authors found that postoperative IIEF erectile function domain scores were significantly higher for patients undergoing IPP compared with grafting procedures (relative to preoperative scores), and patient satisfaction was also higher with IPP and corporoplasty patients relative to the grafting patients.

These data further underscore the importance of patient selection and patient counseling when considering surgical intervention. Our proposed algorithm for surgical treatment in chronic phase PD patients is shown in Fig. 41.1. If the patient has severe ED unresponsive to oral PDE5Is, placement of an IPP with adjunctive straightening maneuvers (manual modeling, plication, or incision and grafting) is indicated. On the other hand, if the patient has no ED or ED that is

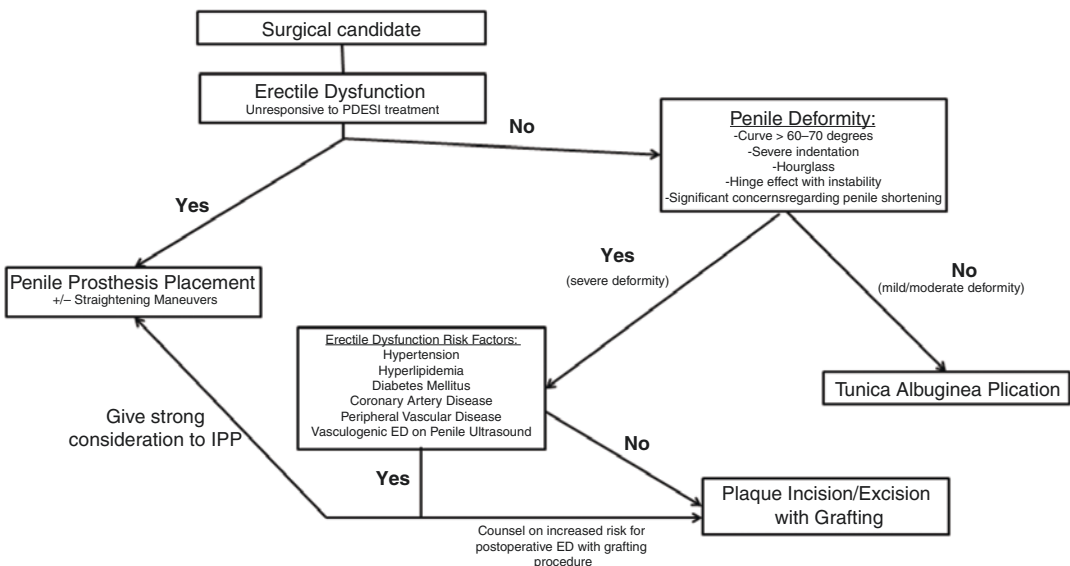


Fig. 41.1 Algorithm for surgical management in Peyronie's Disease

responsive to oral PDE5Is, surgical straightening without IPP should be considered. For patients with mild to moderate deformity (curvature $<60^\circ$, absence of severe destabilizing indentation/narrowing), tunica plication with a variety of techniques can produce excellent outcomes with high patient satisfaction. For those with severe deformity (curvature $>60\text{--}70^\circ$, severe indentation/hourglass with destabilizing hinge), or those with mild to moderate deformity and significant concerns regarding penile length loss, various techniques for incision or excision and grafting may be used. However, patients with risk factors such as evidence of vasculogenic ED on preoperative penile ultrasound, hypertension, hyperlipidemia, heart disease, and coronary artery disease should be extensively counseled about the increased risk for postoperative ED as well [18]. Importantly, grafting and plication procedures do not preclude subsequent IPP placement in the setting of postoperative ED. However, patients with multiple risk factors for ED are excellent candidates for primary penile prosthesis placement at the get-go. Finally, it is important to note that, if IPP is indicated, this may be performed during the acute phase of PD to prevent subsequent disease progression including additional penile length loss.

41.3 Penile Prosthesis Placement

IPP placement can be performed through penoscrotal, infrapubic, or subcoronal approaches (See Chaps. 44 and 45). In all instances we recommend starting the operation by creating an artificial erection using a standard mixture of 30 cc of normal saline and 30 cc of 1% lidocaine instilled directly into the corpora through a butterfly needle. We prefer placement of the needle through the glans (where future Keith needle puncture sites will occur). It is quite common for the needle to dislodge from lateral shaft placement often causing hydrodistension and/or hematoma which causes distortion of tissue planes. This can make dissection of the neurovascular bundle more difficult. The artificial erection

serves three primary purposes [19]. First, it provides local anesthesia. Second, hydro-distention of the cavernosal tissues allows for easier corporal dilation. Third, and most important, it allows the surgeon to once again evaluate the severity of the penile deformity. In patients without a preoperative diagnosis of PD, it also helps to identify unrecognized curvature that may require additional management. However, the true extent of curvature is often only revealed after placement of the prosthesis. Surgical approach (penoscrotal, infrapubic, or subcoronal) is based primarily on surgeon preference. However, in the case of more severe deformity, the approach may require some modification. For instance, while the authors favor a penoscrotal approach for standard IPP placement, a subcoronal incision may be utilized if incision and grafting is anticipated to allow better exposure for neurovascular bundle mobilization.

The IPP is preferred for most patients, and surgeons may consider placement of the Boston Scientific (Marlborough, MA, USA) CX or CXR versus the Coloplast (Humblebaek, Denmark) Titan standard or narrow back devices [20]. Our preferred cylinder for cases with PD is the Coloplast Titan cylinder based on the strength of the Bioflex cylinder and the ability for patients to utilize only one cylinder if necessary. The Boston Scientific LGX device is not recommended for PD as this tends to exacerbate penile curvature [21]. Recent work suggests that malleable prostheses result in adequate straightening and patient satisfaction in the setting of PD as well despite recent AUA Peyronie's guidelines recommending against their use [5, 22]. Standard IPP placement is beyond the scope of the current chapter, and the reader is referred to the other chapters in this text for detailed descriptions. Penile prosthesis placement alone results in satisfactory penile straightening, defined by many authorities as $<20\text{--}30^\circ$, in 40–70% of patients [23–25]. This appears more likely with a less severe curve [26]. The inflatable cylinders serve as a tissue expander and will tend to produce further straightening with ongoing device use as well, particularly in the first year.

41.4 Manual Modeling

When residual curvature in excess of 20–30° is present, manual modeling may be carried out. The technique was originally described by Wilson and Delk in 1994 [27] (Fig. 41.2). After IPP cylinder placement and corporotomy closure, maximally inflate the IPP cylinders and place rubber shods on the tubing to minimize excess pressure on the device pump. The distal urethra must be protected by grasping the distal glans at the level of the distal prosthesis tips (like forcefully choking a chicken), and the contralateral hand grasps the proximal shaft with digital pressure applied over the corporotomy closures. Bend the penis in the direction opposite the curvature for approximately 60–90 seconds (your hand and forearm should hurt). Remove the rubber shods - at this point you should be able to place an additional 2–3 pumps into the cylinders due to the additional space created by stretching of the fibrotic tunica. Replace the shods and perform the procedure once again for 60–90 seconds. At this

point, you can deflate the device to approximately 70%, which is the level of inflation that is most commonly utilized by patients during penetrative intercourse. If the curvature is <20–30°, you can stop. Otherwise, multiple rounds of modeling may be required. Notably, the penis tends to straighten out further over time during the first year of device use. Indentation and hourglass deformity improve with use as well. IPP with manual modeling is successful in 80–98% of patients, particularly when penile curvature is less severe [20, 21, 23, 27]. In our experience, proximal curves/plaques are much more amenable to modeling than distal curves based on the fulcrum created by the length of the penis distal to the lesion. In their long-term assessment, Wilson and colleagues also identified similar rates of 5-year device survival and patient satisfaction between those who did and did not undergo penile modeling.

Complications with manual modeling are rare, but certainly have been encountered by most high volume implanters. In their original work, Wilson and Delk reported a 3% risk of

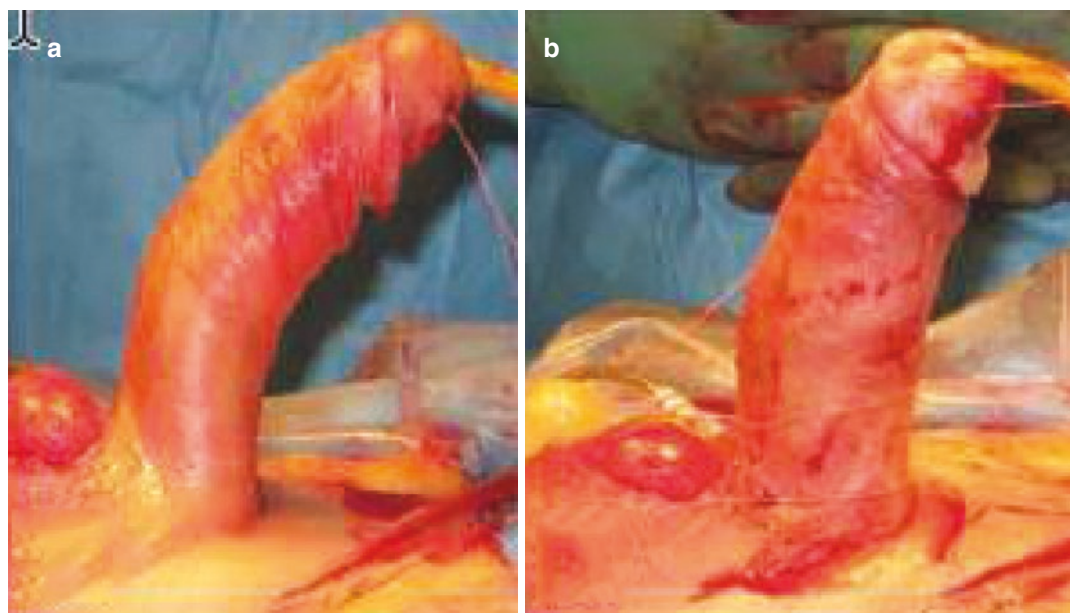


Fig. 41.2 Residual curvature after penile prosthesis placement (a) with further straightening after manual modeling procedure (b)

distal urethral perforation [27]. This occurs from inadequate protection of the glans - the increased pressure on the cylinders forces the distal tip through the relatively thin distal tunic and ultimately the urothelium of the fossa navicularis. If this occurs, the offending cylinder must be removed. However, it may be appropriate to leave the contralateral cylinder in place, and on occasion this provides the patient with enough rigidity for satisfactory sexual intercourse, particularly if a Titan® cylinder is used. Providers should have a high index of suspicion for occult contralateral injury given the explosive perforation force required to cause urethral perforation. Our group has seen delayed urethral erosion ranging from postoperative day one to the test inflation at 3–4 weeks or even several years down the road after modeling was performed at the time of IPP placement. Whether or not the contralateral cylinder is removed, the patient should be treated with urethral catheterization for 2–5 days. The cylinder(s) can be replaced 6 weeks later after cystoscopic confirmation of a normal-appearing urethra. No significant scarring of the corpora occurs in this scenario. Further modifications to decrease the risk of urethral perforation have been described as well [28, 29]. Distal corporal rupture is another complication that may go unrecognized, presenting later with glans edema. If identified intraoperatively, a primary repair via distal partial de-gloving incision can be performed in experienced hands [30]. After experiencing several urethral perforation injuries, our senior author has abandoned modeling in favor of either plication or grafting. This offers the additional advantage of completely correcting the curvature at the time of the additional surgery. Indeed, the inventor of the modeling procedure expresses similar sentiments [31].

41.5 Tunical Plication with Penile Prosthesis

While modeling is the most common maneuver for curve correction following IPP placement, patients may require additional techniques for complete

correction [32, 33]. Furthermore, given the risk of urethral injury with modeling, some implanters, including our senior author avoids use of modeling at all times [34]. Tunical plication is the most common surgery to treat PD in men with adequate erectile rigidity [35]. As such, implanters have adopted this simple technique to correct residual curvature in IPP patients with or without penile modeling.

Multiple iterations of the technique have been described [36, 37]. The point of maximum curvature is identified with an intraoperative artificial erection. Exposure of the corporal bodies can be performed through a ventral midline, penoscrotal, or subcoronal incision. Plication sutures should be placed prior to IPP placement to avoid injury to the prosthetic cylinders. In 2004, Rahman et al. was the first to publish their technique through a ventral midline incision [36]. They utilized 1–2 pairs of 2–0 non-absorbable braided sutures placed using their previously described 16-dot technique [38]. The plication stitches were left untied and tensioned following IPP placement to correct residual curvature. In their initial series, all five patients had complete curvature correction without recurrence or adverse event. Chung et al. described their technique through a high scrotal incision that is mobilized to expose the corpora [37]. Unlike the previous approach described by Rahman, their plication sutures are tied prior to IPP placement to completely correct penile curvature before placement of the device. For our approach, we utilize a penoscrotal incision with cephalad mobilization to expose the corpora. We have found excellent results placing 2–0 Ethibond (Ethicon, Inc., Bridgewater, NJ, USA) sutures using the 16-dot technique and wait to tension the sutures until after IPP placement. If the curve is completely corrected by the IPP alone, the sutures can be removed (Fig. 41.3).

Patients undergoing IPP placement with tunical plication benefit from the ability to attain complete curve correction at the end of the case compared to modeling alone. This technique can be utilized in patients with severe curve ($>90^\circ$) as well as those with biplanar or complex curvatures [36, 37]. Unlike plaque incision, there is no need for neurovascular bundle mobilization or the added infectious risk of grafting. As such, there is minimal added operative time and a lower risk of

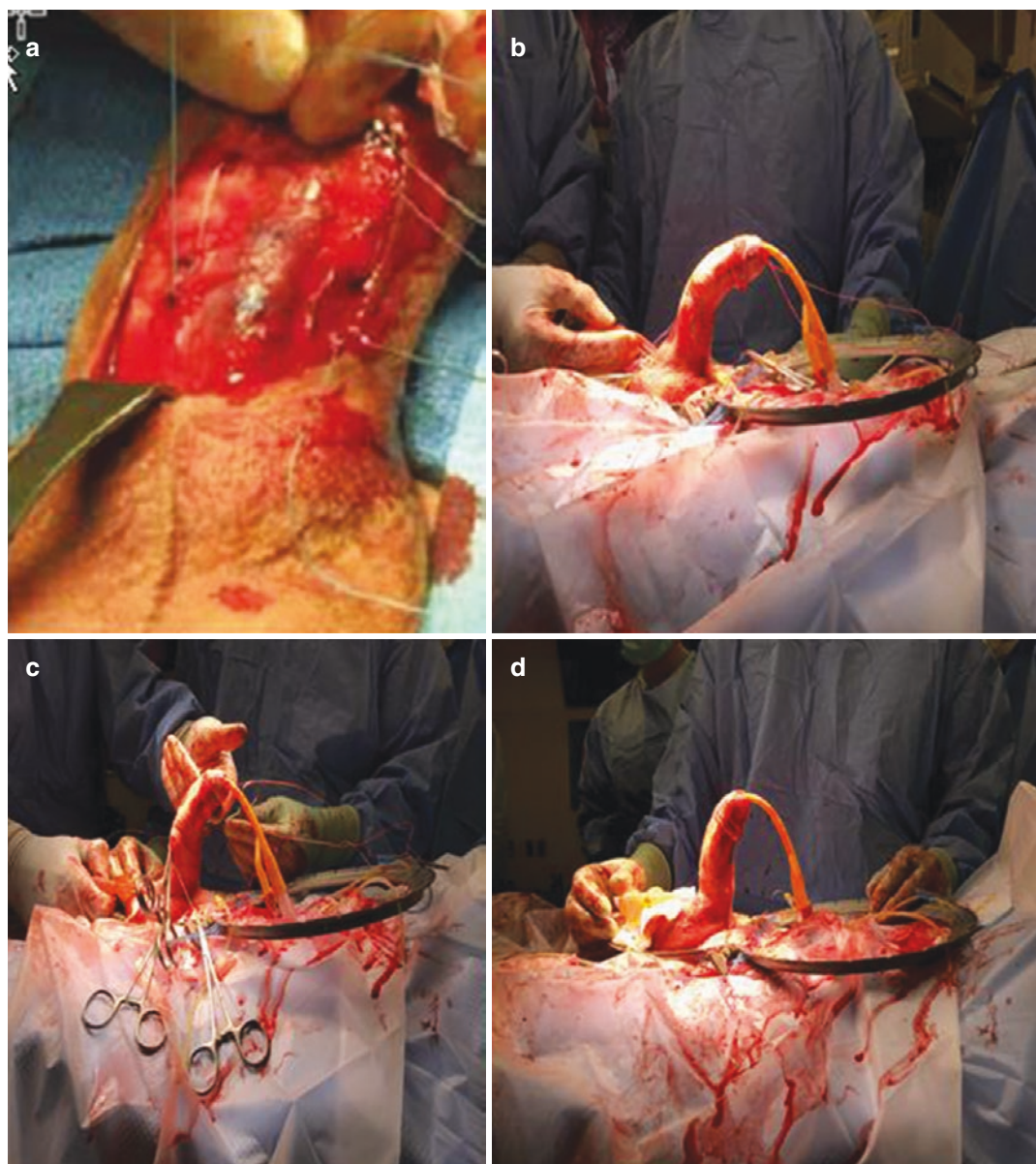


Fig. 41.3 Plication for Peyronie's Disease at the time of penile prosthesis placement. (a) Plication sutures are placed prior to implant at the point of maximum curvature utilizing a 16-dot technique, (b) Cylinders are inflated to

evaluate residual curvature after device placement, (c) Tension is placed on the sutures to evaluate for curvature correction, (d) Sutures are tied down with the device maximally inflated – excellent straightening is appreciated

altering penile sensation [39]. However, in our experience, application of plication in patients with greater than 60° curve leads to suboptimal outcomes including risk for penile shortening.

While patients report excellent curve correction with this technique, plication alters the normal side

of the corpora to match the diseased side. This may lead to shorter penile length, which may be undesirable to patients who have already experienced length loss as a result of PD [37]. In addition, this technique relies on identification of penile curvature prior to IPP cylinder placement [19]. In

patients who have not had adequate erections for years, undiagnosed PD may not be identified until after device placement. A preoperative artificial erection is a useful adjunct, and we feel this should be performed in all patients with a remote history of functional erections and no good erection test in clinic. If curvature is identified after cylinder placement and plication is indicated, subsequent removal of the device to place the plication sutures or risk injuring the cylinders is required. Nevertheless, this technique is a simple and effective adjuvant maneuver for curve correction, especially in patients with adequate penile length.

41.6 Traditional Plaque Incision with Grafting with IPP

Plaque incision and grafting is indicated when IPP placement and manual modeling fail to result in satisfactory penile straightening or correction of “volume-loss” deformity. The need for incision and grafting can often be determined by assessing the severity of the penile deformity during the artificial erection that is created at the start of the case. If a more severe deformity is identified, such as penile curvature $>60^\circ$, it is reasonable to start with a subcoronal approach in order to fully expose the neurovascular bundle. The IPP cylinders are then placed in standard fashion and manual modeling is performed. If residual curvature $<20\text{--}30^\circ$ is achieved, further intervention is unnecessary. However, the concept of a “functionally-straight” penis needs to be discussed with the patient preoperatively. If he desires to be “arrow-straight”, additional maneuvers may be indicated.

If incision and grafting is felt to be necessary, the neurovascular bundle should be elevated dorsally in standard fashion starting just lateral to the urethral ridge on each side for primary dorsal or dorsolateral curvature. If primary ventral curve is present, the urethra may need to be mobilized as well. The point of maximal curvature is then identified and electrocautery with cut current is used to create a releasing incision at this location. This creates a defect of variable size, depending on the severity of the deformity and size of the incision. While some authors have suggested that

small defects $<2\text{-cm}$ can be left open with simple coverage using Buck’s fascia, we have found that defects are rarely this small [40]. Moreover, there is a potential for device herniation without placement of a supporting graft over the defect, even if the defect is relatively small. As such, we recommend grafting in most circumstances.

A variety of graft materials are available, and the type of graft utilized is dependent on a variety of factors including the size of the defect, surgeon preference, and institutional availability. To date, comparative data regarding the various types of tunical grafts is limited, and what comparative data is available is limited to retrospective reviews [41]. Over the last several years, there has been an increased interest in utilizing sutureless graft materials such as Tachosil (Baxter Healthcare, Deerfield, IL, USA) (Fig. 41.4). A recent retrospective study reported similar post-



Fig. 41.4 Tachosil Fibrin Sealant Patch - Distributed by Baxter in the US and Takeda in Europe

operative outcomes with Tachosil or small intestinal submucosa grafts, with a significantly shorter operative time seen with Tachosil.

Our preferred sutured graft material is Tutoplast (Coloplast Corporation, Humlebaek, Denmark) human pericardium allograft because it is thin, strong, and less likely to contract as opposed to other types of biografts [42]. The tunical defect is measured and the graft is cut to size on the back-table. The graft may be oversized by a few millimeters. The prosthesis cylinders are then deflated and a device protection instrument can be used to shelter the cylinders from injury during suture placement. The four corners of the graft are sutured into place in the corners of defect with 4-0 PDS suture on an RB-1 needle. Additional sutures in the midline on the distal and proximal ends of the graft can be placed to better secure the graft as well. The incision lines are then loosely run along each of the four ends, transversely and longitudinally. The prosthesis is then inflated to assess for satisfactory straightening. Buck's fascia is then re-approximated with a 4-0 chromic suture bilaterally. The remainder of the prosthesis can then be placed in standard fashion.

41.7 Novel Plaque Incision with Grafting and IPP

Traditional plaque incision and grafting with IPP can be quite time consuming given the need for meticulous closure of the graft above an in situ, vulnerable implant. In addition, the initial corporal defect created to straighten the penis with the IPP in place is typically created as a rectangle to facilitate appropriate graft sizing and fit. However, despite best efforts several additional corporal incisions or even plication sutures may be necessary to completely straighten any residual curvature after the first grafting attempt. The use of Tachosil and other grafts like Everest® fibrin sealant patch (Ethicon US, LLC; Sommerville, NJ, USA) obviate these issues. For a more thorough description of Tachosil please see Chap. 40.

Our technique with Tachosil combined with IPP has evolved in collaboration with Dr. Hatzichristodoulou and his work [43, 44] (Fig. 41.5). In cases where we know severe curve exists we begin the case utilizing a subcoronal incision with degloving (non-circumcized patients must be circumcized to avoid prolonged swelling distal to the graft). After adequate exposure of the proximal corpora using hand held retractors, the

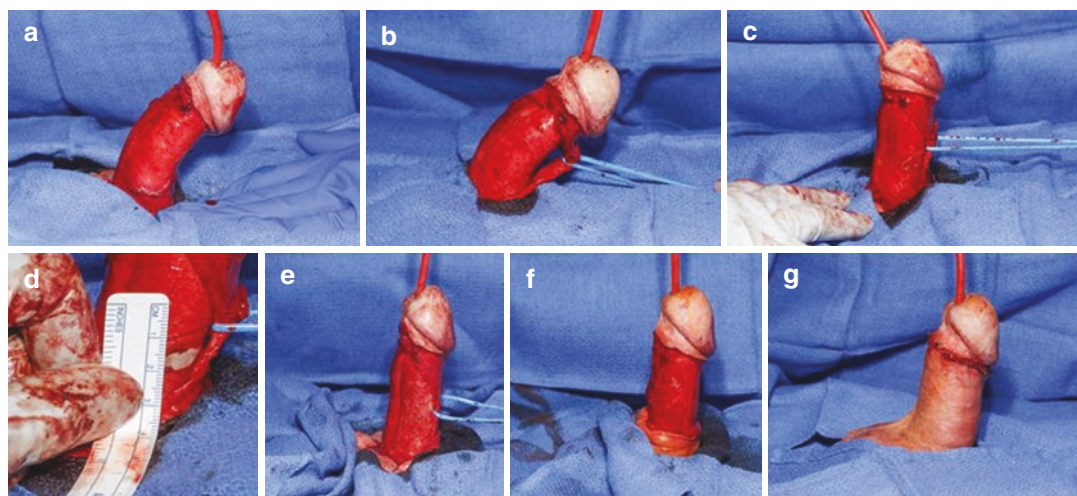


Fig. 41.5 Tachosil graft placement at the time of penile prosthesis for severe penile curvature. (a) Approximately 60-degree residual curvature is identified after cylinder inflation, (b) The neurovascular bundle is raised in standard fashion, (c) A linear incision is created along the dorsal corpora at the point of maximum curvature with the

device 70% inflated – this will expand to create an elliptical defect, (d) With maximal inflation, a 2-cm defect is identified requiring grafting to prevent device herniation, (e) Tachosil patch is sized to cover the defect, (f) Buck's fascia is re-approximated to support the underlying graft, (g) Final appearance after skin closure

corporotomies are made as proximal as possible to avoid tubing being visible through the skin. A Coloplast Titan device is then placed in a standard fashion. Reservoir placement is easier than with a standard penoscrotal incision as the external ring is easily accessible. The pump is placed in the dependent inferior scrotum along with a drain and the device cycled. Device sizing is based on penis on maximum stretch and rarely changes after incision of the Peyronie's plaque. With maximum inflation, the true extent of the curve is noted and point of maximum curvature demarcated. The IPP is cycled into varying states of inflation to facilitate dissection of the neurovascular bundle. Incisions into the dartos onto the squeaky clean corpora begins relatively close to the urethra at the 4 and 8 o'clock position. Ultimately, this flap will be reattached to the periurethral tissue. The neurovascular bundle dissection is carried out using a tenotomy scissors or ceramic metzenbaum scissors and hugs the tunica albuginea. In areas of calcified plaque, one should err under the plaque (with care taken to not injure the IPP) as holes into the corpora are irrelevant and will be covered by the graft. After full dissection of the neurovascular bundle at one point, a vessel loop is used to facilitate release of the entire neurovascular bundle proximally and distally. Often the extent of curve is improved with just mobilization of the neurovascular bundle. Keep in mind that the graft requires about 1 cm of overlap onto the native corpora around the perimeter of the exposed IPP. With the device at about 70% inflation, the point of maximum curve is opened with electrocautery on CUT 30 perpendicular to the urethra. As the incision is taken across the plaque the linear incision will expand to that of an ellipse exposing a window of the device. The amount of device exposed correlates with length gained. If the plaque is very calcified, heavy instruments may be required to incise or cut out the lesion. Occasionally, portions of the plaque will require excision as sharp edges that remain could puncture the device (Fig. 41.6). If the penis is not totally straight with the initial incision, the ends of the incision can be opened but this time parallel to the incision, an H incision if done on both sides (Fig. 41.7). The penis should then become totally straight.

The Tachosil is briefly submerged in normal saline for 30 seconds and used to cover the defects with adequate overlap of 1 cm onto native cleaned corpora with the adhesive yellow portion of the graft facing downward. The graft is molded into place and Buck's fascia is closed. The neurovascular bundle provides support for the underlying graft. This can be done with interrupted 5–0 monocryl or running sutures on either side. Beware not to steal coverage from one side with overly aggressive bites on the first side. Finally, the skin is reapproximated in 2 layers. The device is left inflated for several weeks and left full enough to let the graft set. The patient can use the device for intercourse after 6 weeks.

Combined experience of Dr. Hatzichristodoulou and our group has yielded excellent results without infectious complication. After >50 patients, 2 patients have complained of poor pump placement requiring surgical revision. It seems as though the graft may cause an inflammatory reaction that draws the pump toward the penoscrotal junction. A subcoronal incision sometimes requires additional time to heal and will be problematic if the patient is not circumcised. Furthermore, residual curve can remain if additional incisions are not made as described above. Our group and Dr. Hatzichristodoulou have had success with this approach in one patient each for a severe ventral curve. In this case, the urethra is mobilized off the ventral corpora and plaque incision performed across the lesion (Fig. 41.8).

41.8 Miscellaneous Maneuvers

While, manual modeling, tunical plication, and incision and grafting are the most common techniques for curvature correction, high volume implanters have developed techniques that deserve discussion. For example, Perito and Wilson developed the "scratch" technique to disrupt the Peyronie's plaque in three dimensions [28]. The technique is described for infra-pubic IPP placement. If curvature or other deformity suggestive of PD is identified during artificial erection, the authors describe passing

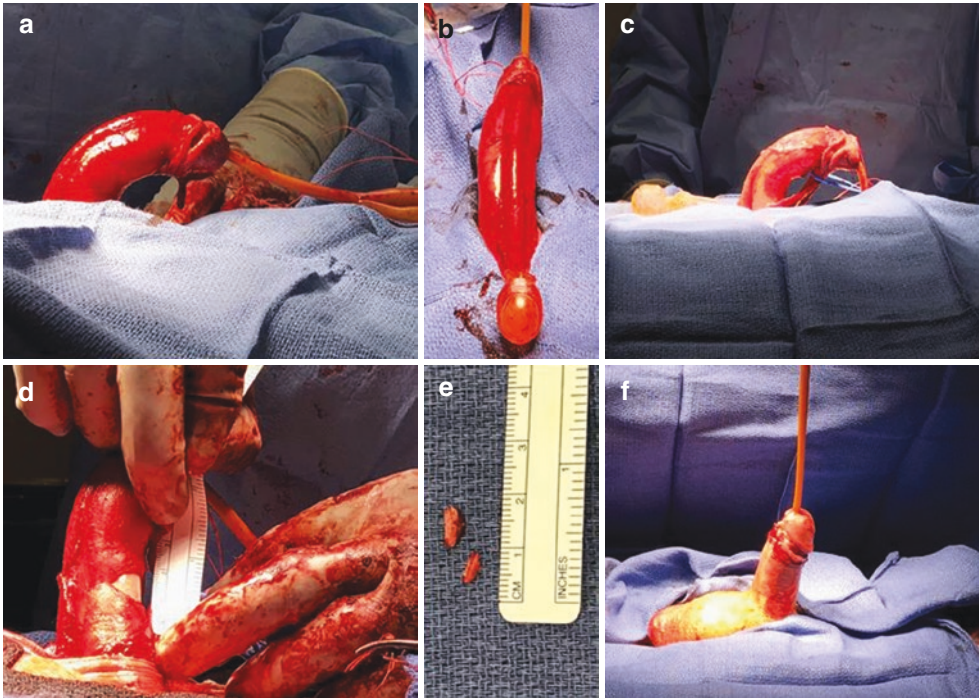


Fig. 41.6 Example of severe penile deformity with calcified plaque (“plate of bone”). (a) 90-degree dorsal penile curvature along with mid-shaft hourglass deformity (b) present after cylinder placement, (c) Neurovascular bundle dissection results in minimal cur-

vature improvement, (d) A linear corporal incision is made with expansion creating an elliptical defect, (e) Calcified plaque with “bone chips” may require sharp excision to prevent injury to the underlying cylinders, (f) Final result after skin closure

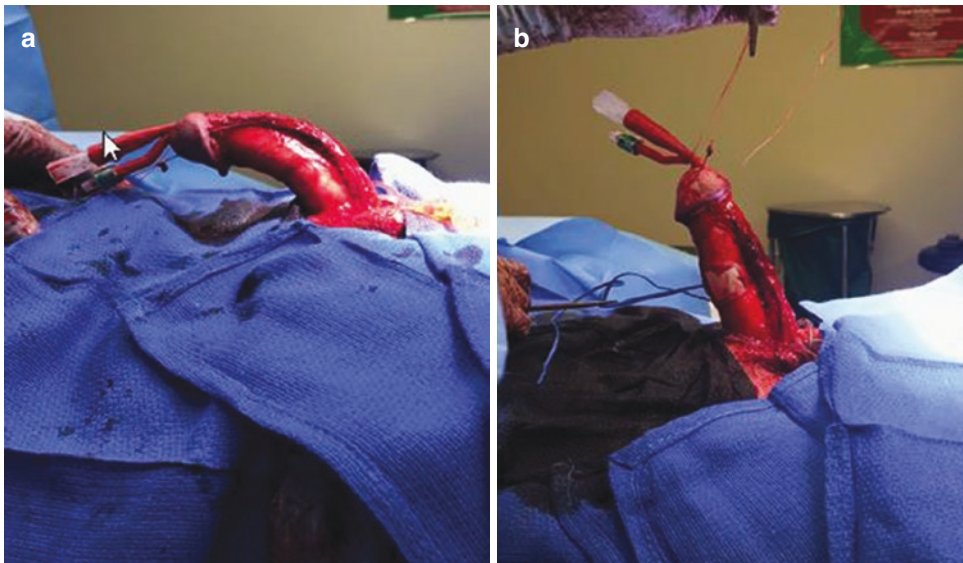


Fig. 41.7 Massive corporal defect after plaque incision. (a) Severe dorsal penile curvature with narrowing, (b) “H-type” incision is carried out laterally to allow for

plaque release and adequate straightening, (c) Large corporal defect with greater device exposure, (d) Tachosil graft placed for adequate coverage

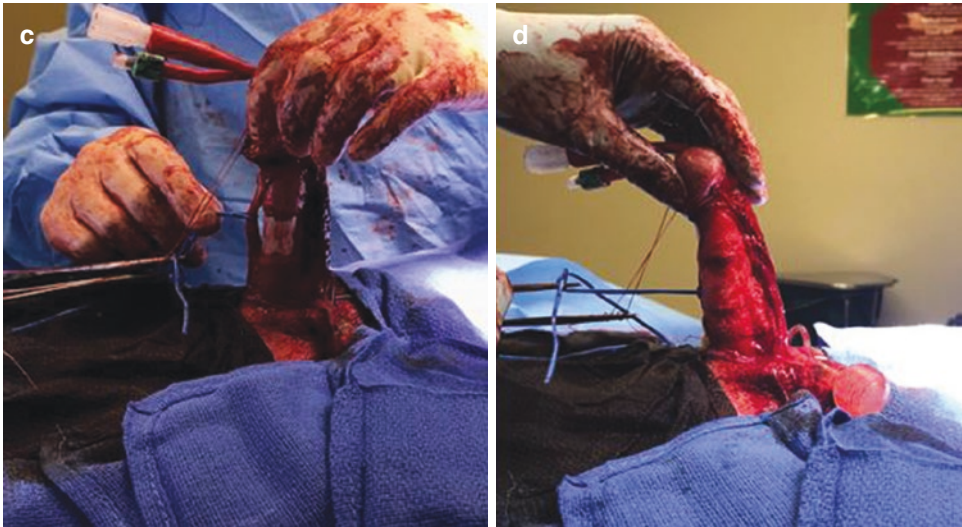


Fig. 41.7 (continued)

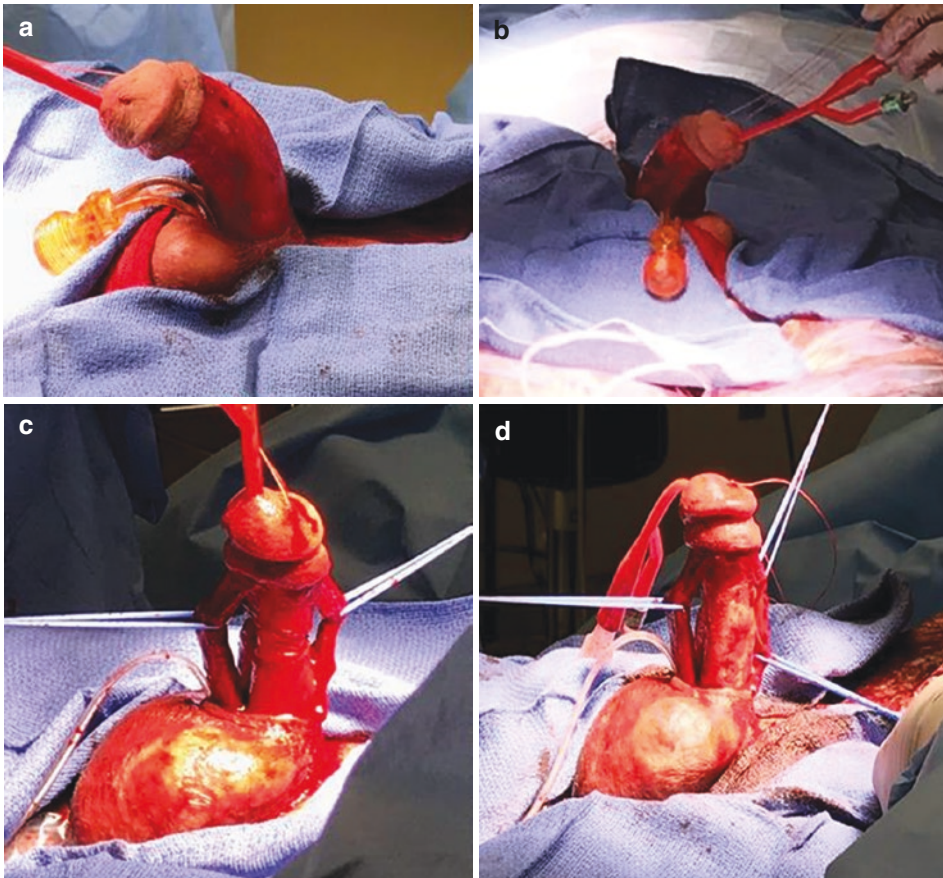


Fig. 41.8 Ventral penile curvature. (a/b) Complex ventrolateral curvature remains after cylinder placement, (c) Mobilization of the neurovascular bundle and urethral for exposure of the ventral plaque – a linear incision is per-

formed along the ventral corpora extending laterally (approximately 270°), (d) Tachosil patch is used to cover the defect with excellent straightening identified

an 80-mm nasal speculum distally through the corporotomies and opened to “fracture the plaque” along the x-axis. A 12 blade is then inserted into the corpora to “scratch”, the plaque disrupting it along the y-axis. The depth of the “scratch” further disrupts the plaque along the z-axis. Following this, the implantation is completed. Any residual curvature is then corrected with manual modeling. The authors state that, by weakening the plaque, the force needed for modeling and the risk of urethral injury is hypothetically reduced. In 2018, Antonini et al. reported their use of the “scratch” technique with postoperative vacuum assist device in 145 patients [45]. Mean curvature was 65.8° preoperatively and 19.8° following the “scratch” technique with manual modeling. The addition of vacuum device therapy for 3 minutes twice daily subsequently reduced the residual curvature at 1 year to 10°, which represented a statistically significant improvement. Nine (6.2%) patients reported recurrent or persistent curvature >15° at 1 year. Additionally, 3 patients experienced impending lateral extrusion of the IPP cylinders that was corrected using the distal corporeal anchoring stitch technique [46].

Montorsi and colleagues have described a feathering technique, to correct penile curvature and improve penile length in 10 patients [47] (Fig. 41.9). Through a subcoronal incision, the neurovascular bundles are mobilized off of the tunica albuginea. Rather than making a single large incision over the Peyronie's plaque, which may require graft placement for added support, multiple relaxing corporal incisions are made approximately every 1 cm over the area of deformity. The corporotomy and device placement are then performed through a second penoscrotal incision. Using this technique, the gaps in the tunica remain small and therefore grafting is unnecessary. While patients experienced on average a 3 cm increase in erectile length at 6 months, 4/10 (40%) patients experienced persistent decreased penile sensitivity, and 1 patient required an additional procedure for residual curve correction.



Fig. 41.9 Corporal feathering to address penile curvature at the time of prosthesis placement – this requires mobilization of the neurovascular bundle

41.9 Conclusion

Patients with bothersome PD and ED benefit from IPP with or without adjuvant maneuvers. Fortunately, for the implanting Urologist, multiple techniques as described above are available. While it is not necessary to be well versed in all of the aforementioned techniques, when implanting a PD patient, the Urologist should be prepared to apply adjuvant maneuvers as indicated.

Key Summary Points

- Comorbid erectile dysfunction is present in approximately 30–45% of patients with Peyronie's Disease
- In patients with severe erectile dysfunction or significant deformity (penile curvature > 60°, hourglass/indentation with hinge-effect) and risk factors for erectile dysfunction, penile prosthesis placement with simultaneous straightening maneuvers should be strongly considered
- Penile prosthesis alone results in adequate straightening in 40–70% of patients

with mild deformity – those with more severe deformity are more likely to require adjunctive procedures

- Manual modeling may be used to treat residual curvature after penile prosthesis cylinder placement, although care must be taken to avoid distal urethral perforation
- Tunica albuginea plication with suture placement prior to prosthesis cylinder insertion results in excellent outcomes, but may result in penile shortening with more severe penile curvature
- Plaque incision with grafting using a variety of graft materials results in excellent outcomes, although care must be taken to avoid injury to the cylinders if left in place at the time of grafting
- Several sutureless graft materials including Tachosil are available for incision and grafting with penile prosthesis placement and avoid the need for suture placement – decreasing operating times and preventing the risk for device injury

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Modern Strategies for the Surgical Treatment of Priapism

42

Amanda B. Reed-Maldonado and Tom F. Lue

42.1 Introduction

Priapism is a relatively uncommon condition, but it is among the most challenging of urologic emergencies. The incidence of priapism among males in the United States is approximately 1.5 per 100,000 person years [1], but this may be an underestimation of the true incidence as many patients likely do not seek medical care [2]. Advances in understanding the pathophysiology of various types of priapism have led to effective targeted therapies for the disorder. This chapter aims to summarize contemporary understanding of the pathophysiology of priapism and to outline a systematic management strategy based on expert consensus combined with current clinical guidelines. We will include both the most recent research in addition to classical urological references to be thorough, but we have developed a duration-based treatment strategy for priapism that we hope will be a helpful decision-making tool for urologists and patients both.

Peer-reviewed, best-practice guidelines for the treatment of ischemic priapism are available [3, 4], but randomized controlled trials of ischemic priapism will likely never be accomplished as priapism is an emergent condition and accrual would be virtually impossible. The American Urological Association (AUA) guidelines, first published in 2003 and validated in 2010, are grounded in the best available scientific and clinical evidence combined with expert opinion [3]. The European Association of Urology (EAU) guidelines, first published in 2014, are based on systematic literature review for the best available evidence [4]. These documents are informative and useful, but both omit one of the key requirements of treatment for ischemic priapism: periprocedural anticoagulation (Fig. 42.1).

Though basic science and clinical research continues regarding the etiologies of and treatments strategies for priapism, the disorder remains challenging to treat and methods of prevention remain elusive. To be comprehensive, we will present in this chapter several novel concepts that have not been previously incorporated into previous priapism treatment algorithms: prevention of ischemic priapism using medications including phosphodiesterase-5 inhibitors and botulinum toxin; anticoagulation in combination with shunting procedures [5]; and employment of MRI to determine the appropriate patients for observation versus early prosthesis placement [6].

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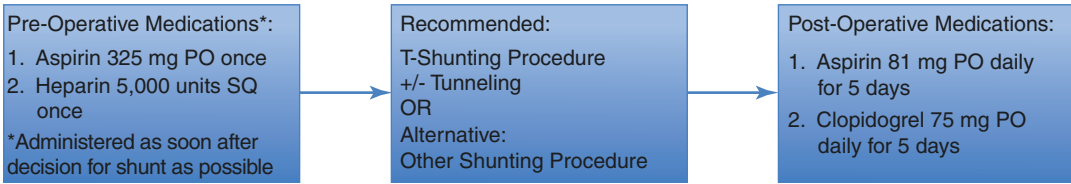


Fig. 42.1 Recommended algorithm for peri-shunt anticoagulation. Peri-shunt anticoagulation ensures that the shunt remains patent long enough to allow for complete resolution of ischemic priapism. Antiplatelet medication

is discontinued after 5 days to allow the shunt to clot, which allows for recovery of erectile function and prevents maturation of the shunt, which may cause ED. ED erectile dysfunction

42.2 Definition

Priapism is defined as a prolonged and persistent penile erection unrelated to sexual stimulation, lasting longer than 4 hours in duration [3]. **Three main types** of priapism have been characterized: **ischemic** (venoocclusive, or low-flow), **non-ischemic** (high-flow), and **recurrent ischemic** (stuttering). The preferred terms are “ischemic” and “non-ischemic” as they suggest the urgency of both the diagnosis and the intervention [6]. Rapid treatment of ischemic priapism is essential to ensure preservation of erectile function and to minimize long-term morbidity, including penile fibrosis with loss of penile length and girth. These are the expected natural consequences of untreated ischemic priapism. In the rare patient with ischemic priapism who is not interested in preservation of erectile function, pain management becomes the focus of therapy.

Treatment for *ischemic priapism* should be initiated with aspiration of the ischemic corpora cavernosa followed by injection of a diluted alpha-adrenergic agent, such as phenylephrine [3]. If this fails, which is common in priapism of more than 24 hours duration, surgical treatment with a distal shunting procedure should be recommended. One of the most frequent and discouraging complications of the surgical treatment of ischemic priapism is shunt failure with recurrent priapism [5]. Shunt failure is secondary to exposure of the blood to collagen during surgical creation of the shunt, leading to clotting which causes premature shunt closure [5]. Perioperative anticoagulation

should be initiated immediately after identifying the need for a surgical shunt procedure and prior to surgical intervention [7]. Timely anticoagulation will minimize shunt failure and maximize treatment success. Anticoagulation should be continued for 5 days after shunt creation to ensure patency while the corporal tissue is reperfused [5, 7].

In *non-ischemic priapism*, current treatment options include observation versus primary medical treatment with antiandrogens, such as bicalutamide or ketoconazole, or GnRH agonists for 3–4 months [8]. Primary medical therapy avoids the need for potentially unnecessary invasive intervention, and short-term medical treatment has minimal associated morbidity. If these conservative measures fail, additional intervention with arterial embolization can be considered. Surgery for non-ischemic priapism is typically the next option if embolization fails. Previous therapeutic algorithms included only observation for 6 months, selective arterial embolization, and surgical intervention as the last resort [3]. The inclusion of conservative options in the treatment algorithm is important as approximately 62% of patients will have spontaneous resolution of symptoms without intervention [9].

Finally, in patients who present with recurrent ischemic priapism, or *stuttering priapism*, androgen ablation therapy is an effective, proven therapy for most patients. In young men with sickle cell disease, however, treatment with low dose type 5 phosphodiesterase (PDE5) inhibitors may be an effective alternative [10]. There are no other proven prevention strategies for stuttering priapism at this time.

42.3 Patient Evaluation and Assessment

42.3.1 History and Physical Examination

The first step in evaluation of a patient with suspected priapism is to take a rapid, focused history of the priapism episode. The history may suggest an etiology and may suggest the most effective treatment (and prevention) strategy. Important information to discuss includes:

- Duration of penile erection
- Degree of penile pain (ischemic priapism is painful while nonischemic priapism is usually not painful)
- Previous history of priapism and its treatment
- Use of drugs that might have precipitated the episode. Drugs that have been associated with priapism are: anti-hypertensives; anticoagulants; antidepressants and other psychoactive drugs; alcohol; marijuana; cocaine and other illegal substances; vasoactive agents used for intracavernous injection therapy such as alprostadil, papaverine, prostaglandin E1, phentolamine, and others.
- History of pelvic, genital, or perineal trauma, especially a perineal straddle injury
- History of sickle cell disease or other hematologic abnormality

The genitalia, perineum, and abdomen should be carefully examined for evidence of trauma, malignancy, or previous surgical intervention. In ischemic priapism, the corpora cavernosa are rigid and painful while the corpus spongiosum and the glans penis remain soft. In patients with non-ischemic priapism, the corpora are typically tumescent but not be completely rigid nor painful.

42.4 Laboratory and Radiologic Evaluation

Laboratory evaluation should not delay treatment. Critical information includes a complete blood count (CBC) with special attention to the white

blood cell count, the white blood cell differential, the reticulocyte count, and the platelet count. Acute infections or hematologic abnormalities, such as sickled red blood cells, leukemia, or platelet abnormalities, can cause priapism and may be identified by the CBC. The reticulocyte count is often elevated in men with sickle cell anemia. Hemoglobin electrophoresis identifies the presence of sickle cell disease or trait as well as other hemoglobinopathies. A reticulocyte count and hemoglobin electrophoresis should be considered in all men unless there is another obvious cause of priapism, but these tests should not delay intervention. Screening for sickle cell disease or trait should be performed by either the Sickledex test or examination of a peripheral smear with subsequent confirmation using hemoglobin electrophoresis. Screening for psychoactive drugs and urine toxicology may be performed as overdoses of legal and illegal drugs may cause priapism.

In addition to the physical examination and the aforementioned laboratory tests, penile corporal blood gas analysis and penile color duplex ultrasonography are currently the most dependable adjunctive diagnostic methods to distinguish ischemic from nonischemic priapism, though history physical exam alone typically clinch the diagnosis. Blood aspirated from the corpus cavernosum in patients with ischemic priapism is hypoxic and typically has a $PO_2 < 30$ mm Hg, $PCO_2 > 60$ mm Hg, and $pH < 7.25$. Cavernous blood gas in nonischemic priapism is similar to arterial blood gas with $PO_2 > 90$, $PCO_2 < 40$, and $pH 7.40$. A normal flaccid penis cavernous blood gas is similar to normal mixed venous blood with a $PO_2 = 40$, and $PCO_2 = 50$, and a $pH 7.35$ [3]. It is to be noted that the corporal blood gas results may remain in the non-ischemic range if the blood is drawn within 4–6 hours after the onset of a recurrent priapism following medical or surgical intervention. Making a diagnosis of a high flow priapism in this situation and subjecting the patient to arterial embolization should be avoided.

Color duplex ultrasonography may be utilized as an alternative to cavernosal blood gas sampling to differentiate ischemic from nonischemic priapism. Patients with ischemic priapism have little or no blood flow in the cavernosal arteries,

while patients with nonischemic priapism have normal to high blood flow in the cavernosal arteries. Duplex may also be performed as a screening test for anatomical abnormalities, such as a cavernous artery fistula or pseudoaneurysm, in men who have nonischemic priapism. For these men, color duplex ultrasonography should be performed in the lithotomy or supine frog-legged position, scanning in the perineum first as this is the most likely location of injury and then along the entire shaft of the penis. Arteriography is reserved for a planned embolization procedure.

Recent clinical studies have suggested that contrast-enhanced penile MRI may also be a useful tool for patients with prolonged ischemic priapism. The goal of MRI in this setting is to identify penile cavernosal smooth muscle necrosis. If there is no evidence of cavernosal smooth muscle necrosis, potential overtreatment with early penile prosthesis can be avoided [6]. A penile MRI may also aid in the decision of whether or not a patient can hope for erectile recovery with a conservative approach or whether early penile prosthesis is the most appropriate option. In one series of 23 patients in which gadolinium-enhanced, high-definition MRI findings were correlated with corpus cavernosum biopsies, penile MRI demonstrated 100% sensitivity in assessing for cavernosal smooth muscle necrosis [11]. Accordingly, this imaging modality may be particularly valuable in supporting the clinical decision to recommend immediate penile prosthesis placement after a prolonged priapism episode rather than conservative treatment with aspiration/injection and surgical shunting.

42.4.1 Epidemiology

Ischemic priapism, with a reported incidence of up to 5.34 per 100,000 men per year, is the most common type of priapism [1]. Although most commonly idiopathic, the disorder disproportionately affects sickle cell disease patients who often experience stuttering priapism [12]. This population has been the subject

of much research into the causes of and treatments for ischemic priapism [13]. Occurring less frequently, non-ischemic priapism is often associated with a history of penile or perineal trauma [2].

42.5 Ischemic Priapism

42.5.1 Pathogenesis

Ischemic priapism occurs when occlusion of the venous outflow from the corpora cavernosa prevents arterial inflow, leading to corporal ischemia, endothelial and smooth muscle injury, and consequent fibrosis [3, 14]. Malignancy, medications (such as anticoagulants, anti-hypertensives, antidepressants, antipsychotic drugs, phosphodiesterase-5 inhibitors [15], trazadone [16–18], cocaine, alcohol, marijuana, amphetamines [19], vasoactive drugs for injection including papaverine, phentolamine, and alprostadil, among others), spinal cord injury [20], and hematologic conditions (such as sickle cell disease and glucose-6-phosphate deficiency) have all been implicated as etiologies of ischemic priapism [4, 21].

42.5.2 Management: Duration-Directed Treatment Algorithm for Ischemic Priapism

The goal of management for ischemic priapism is rapid resolution to ensure preservation of erectile function. The most common sequelae of prolonged ischemic priapism is erectile dysfunction (ED) secondary to corporal fibrosis. Fibrosis is the result of tissue acidosis, glucopenia, and hypoxia with subsequent progression to smooth muscle cell necrosis and transformation of smooth muscle cells into fibroblast-like cells [22]. In fact, *in vitro* studies reveal that hypoxemia, acidosis, and glucopenia may cause irreversible smooth muscle damage as early as 4 hours after onset [22]. Sickle cell disease patients are up to five times more likely to develop ED compared to non-sickle

cell disease patients [23]. Early recognition of ischemic priapism and swift, proficient treatment are critical to prevent this histopathologic cascade and to preserve erectile function. We have developed a straightforward duration-directed treatment algorithm for treatment of ischemic priapism (Fig. 42.2).

42.6 Aspiration and Injection of an α -Adrenergic Agent for Ischemic Priapism

Within the first 24 hours of onset, ischemic priapism should be managed with percutaneous corporal aspiration (not more than 100 ml) through

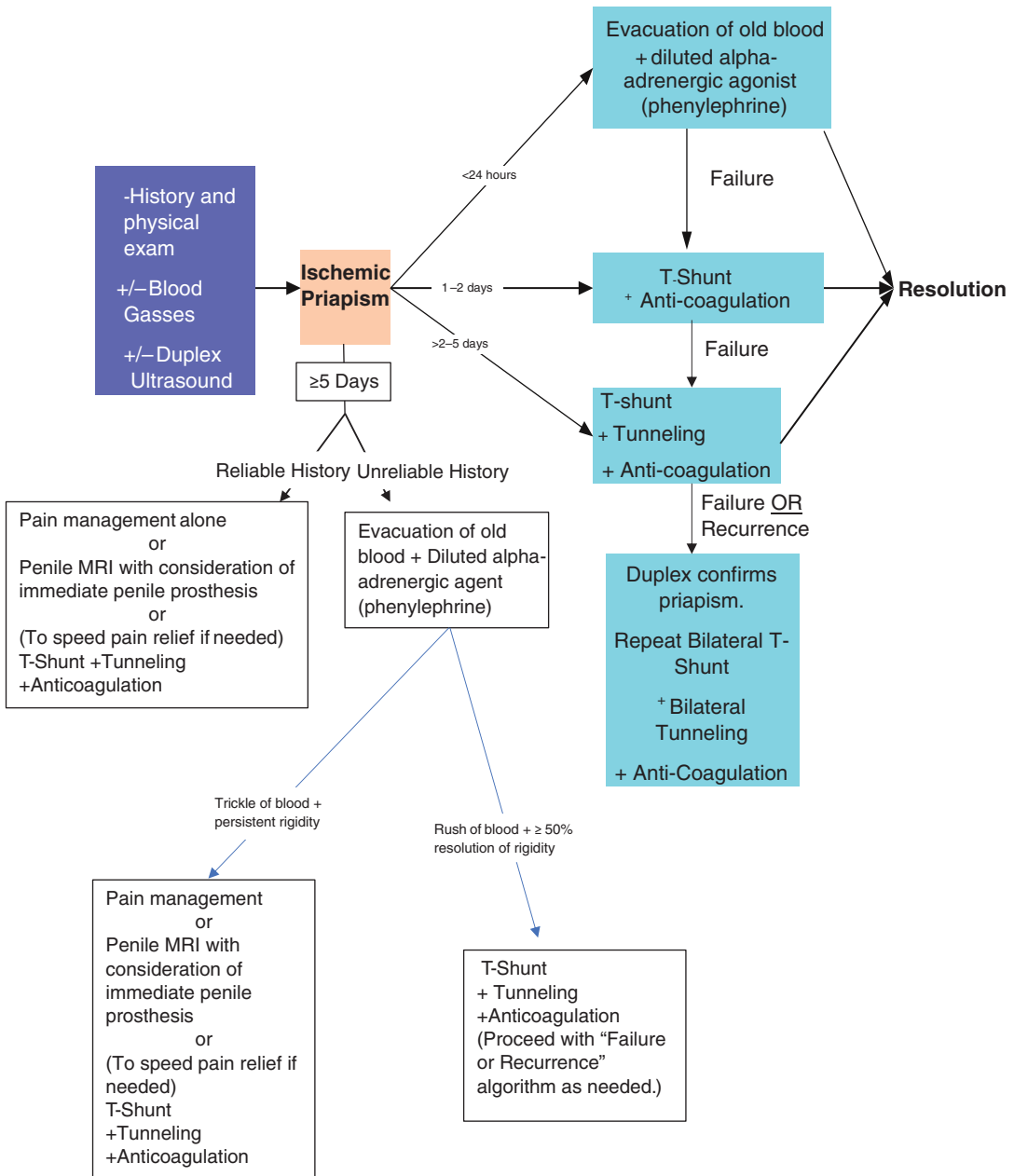


Fig. 42.2 Duration-Based Algorithm for Management of Ischemic Priapism

a 21-gauge or larger scalp vein needle inserted into the lateral aspect of the corporal body at either the 3 or 9 o'clock position (Fig. 42.3). Removal of acidotic blood will facilitate the return of oxygenated blood. Aspiration should be followed by intracavernous injection of a diluted α -adrenergic agent, with the α -1 selective phenylephrine (at a dose of 500 mcg every 3–5 minutes for up to 30 minutes) being the preferred agent due to a lack of β -adrenergic cardiac effects [24]. Additionally, when performing injection with α -adrenergic agents, it is prudent to ensure that the patient has been thoroughly informed of the details and risks of the procedure. It is also judicious to obtain an informed consent for shunting procedures in the event that the α -adrenergic agent injection fails to resolve the priapism.

During the injection procedure, the patient's blood pressure and heart rate should be monitored to assess for changes associated with intravascular injection of α -adrenergic agents, such as hypertension and reflex bradycardia, and to beware of new-onset headache which may result from systemic vasoconstriction. This is particu-

larly important in patients with significant cardiovascular disease.

Conservative interventions (not included in the algorithm) for ischemic priapism may be attempted *only* if there is a delay in active treatment. Conservative measures, including encouraging ejaculation, vigorous physical exercise, and ice packs, aim to induce smooth muscle contraction and detumescence via sympathomimetic α -receptors [6]. Additionally, oral vasoactive agents, such as oral terbutaline 5 mg or oral pseudoephedrine immediate release 120 mg, may be attempted while the urologist is preparing or awaiting medications/supplies, but these agents have been deemed less effective than phenylephrine and may unnecessarily delay delivery of appropriate treatment [25].

42.7 Surgical Techniques for Ischemic Priapism

Beyond 24 hours of onset, or if the injection procedure fails to resolve the priapism, surgical intervention is typically necessary to shunt the

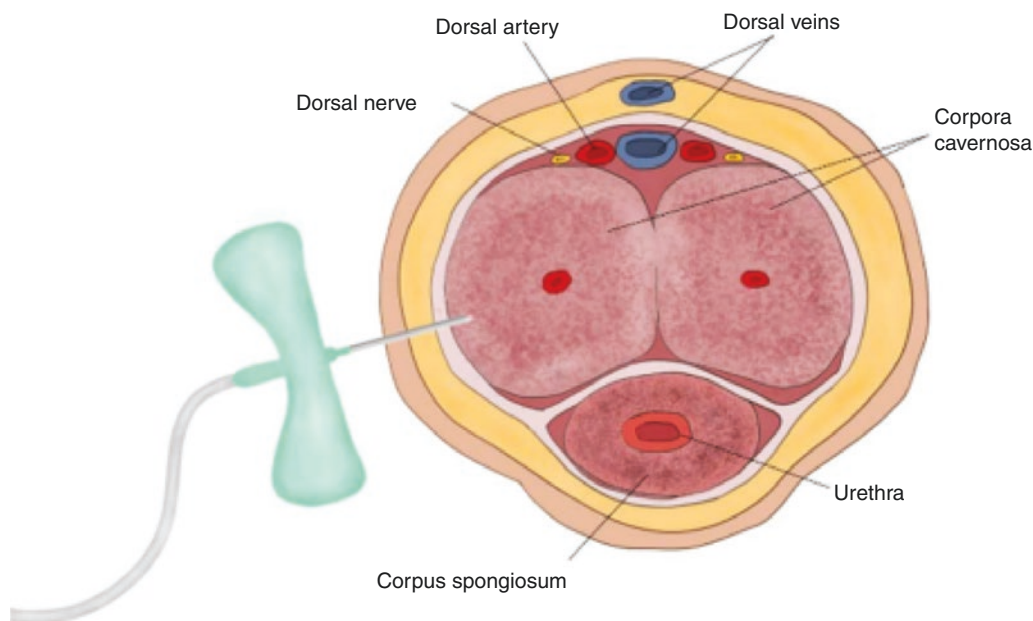


Fig. 42.3 Aspiration and irrigation of the corpora should be performed through a butterfly needle of no smaller than 21 gauge. The needle should be inserted through the

tunica albuginea into the corpus cavernosum. The cavernosa are connected in the midline by the incomplete midline septum so irrigation of one side should be adequate

blood from the corpus cavernosum to the corpus spongiosum, glans penis, or alternative venous channels. There are two types of surgical shunts: distal (Fig. 42.4) and proximal (Fig. 42.5). Preferably, a distal shunt between the corpora and the glans is created using a percutaneous

shunt [Ebbehoj (# 11 scalpel blade) shunt [26], Winter (biopsy needle) shunt [27], unilateral or bilateral T-shunt (# 10 scalpel blade inserted then turned 90°) [28]] or an open Al-Ghorab (excision of the distal tip of the corpus cavernosum through a glans incision) shunt [24].

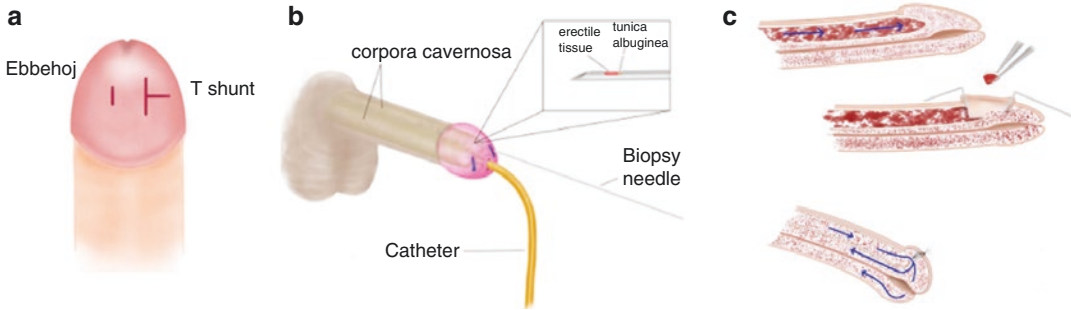


Fig. 42.4 Distal surgical shunting procedures for ischemic priapism. (a) Ebbehoj shunt compared to T-shunt. An Ebbehoj shunt is created using an #11 blade knife to stab through the glans into the distal tip of the corporal body. A T-shunt is created by inserting a #10 blade knife through the glans into the tip of the corpora and rotating the knife

90 degrees leading to a "T-shaped" incision in the glans at completion of the procedure; (b) Winter's shunt. A biopsy needle is used to punch a core out of the tunica albuginea at the distal tips of the corpora cavernosa; (c) Al-Ghorab shunt. The distal tips of the corpora cavernosa are removed through an incision in the glans penis

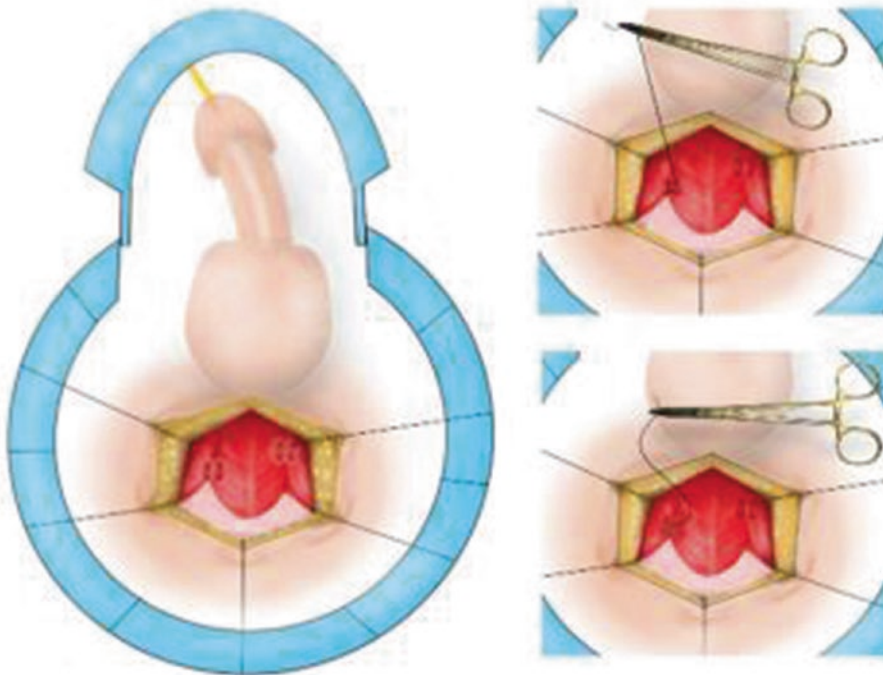


Fig. 42.5 Proximal surgical shunting procedures for ischemic priapism. A Quackels (perineal approach) shunt is created from the corpus cavernosum to the corpus spongiosum at the level of the bulbar urethra where the sponge is most robust and the urethra is relatively further from the

shunt. If this procedure is performed from a penoscrotal incision, it is named the Sacher approach. At the penoscrotal junction, the spongiosum surrounding the urethra is thin, increasing the risk of fistula formation

Proximal shunts are not recommended. These shunts create a connection between the corpora and the proximal spongiosum and include the Quackles (perineal approach) [29] and the Sacher (penoscrotal approach) [30]. Venous shunts (Fig. 42.6) connect the corpora to a vein and include the Greyhack (corpora to saphenous vein) [31] and the Barry (corpora to dorsal vein of the penis) shunts [32].

The choice of shunt often depends on surgeon familiarity but should proceed from least to most invasive. The efficacy of the T-shunt (Fig. 42.7) nears 100% when combined with anticoagulation to ensure patency of the shunt and with the use of corporal dilators passed through to the proximal penis. This maneuver physically removes stagnant blood within the corpora [33–35]. The sole surgical shunting procedure in our algorithm is the transglanular T-shunt (+/- tunneling) (Fig. 42.8) as it is the most efficient and effective method, it is easy to perform, it requires minimal equipment, preparation or personnel support, and it has the fewest associated surgical risks.

For patients with an ischemic priapism duration of longer than 48 hours, severe intracavernous tissue edema may prevent effective blood flow from the proximal to distal penis [14]. In the past, the Quackles proximal shunt [29] and the Barry cavernosum-venous shunt [32] have been the standard approaches in these cases. However, proximal shunts are more difficult to perform, they are time-consuming, and they are associated with an increased risk of complications. Therefore, proximal shunts have been replaced by shunting procedures which incorporate tunneling maneuvers as developed by Lue et al [35, 36] and Burnett et al [33, 34] (Fig. 42.9).

Most importantly, all of the above shunting procedures involve surgical incision through the tunica albuginea and thus expose the blood to collagen, which is the most powerful initiator of blood clotting *in vivo* (Fig. 42.10). This activates the clotting cascade and renders these shunts susceptible to rapid thrombosis [5]. Perioperative anticoagulation is the most important element of successful resolution of

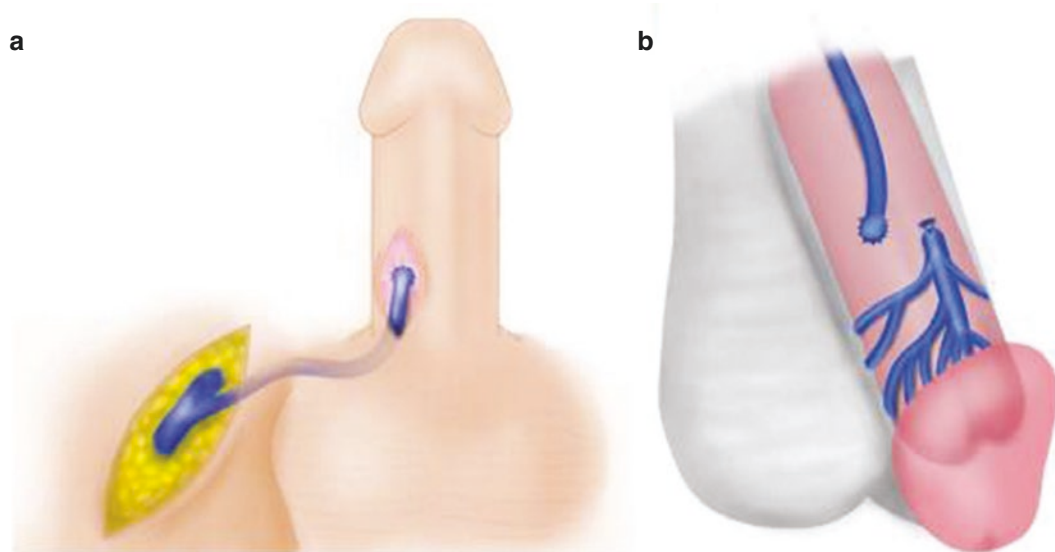


Fig. 42.6 Venous shunting procedures. (a) Greyhack shunting procedure. The saphenous vein is anastomosed to the tunica albuginea of the corpus cavernosum to allow

for continuous outflow of blood; (b) Barry shunting procedure. The dorsal vein of the penis is anastomosed directly to the tunica albuginea of the corpus cavernosum

Fig. 42.7 Surgical technique for T-shunt procedure. **(a)** A #10 blade knife is inserted through the glans penis to the hub of the blade. The knife handle is rotated 90° laterally then withdrawn to enlarge the tunical defect; **(b)** an opening, or shunt, is created from the corpus cavernosum through the glans penis to the corpus spongiosum to allow evacuation of blood from the ischemic corpora and to accommodate the high flow state of post-ischemic hyperemia

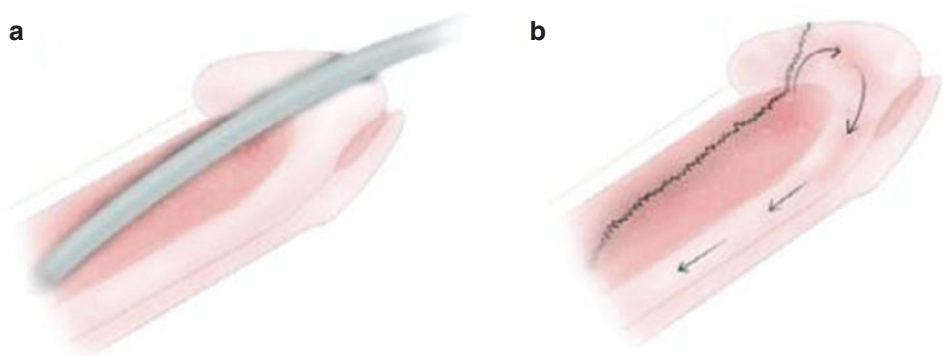
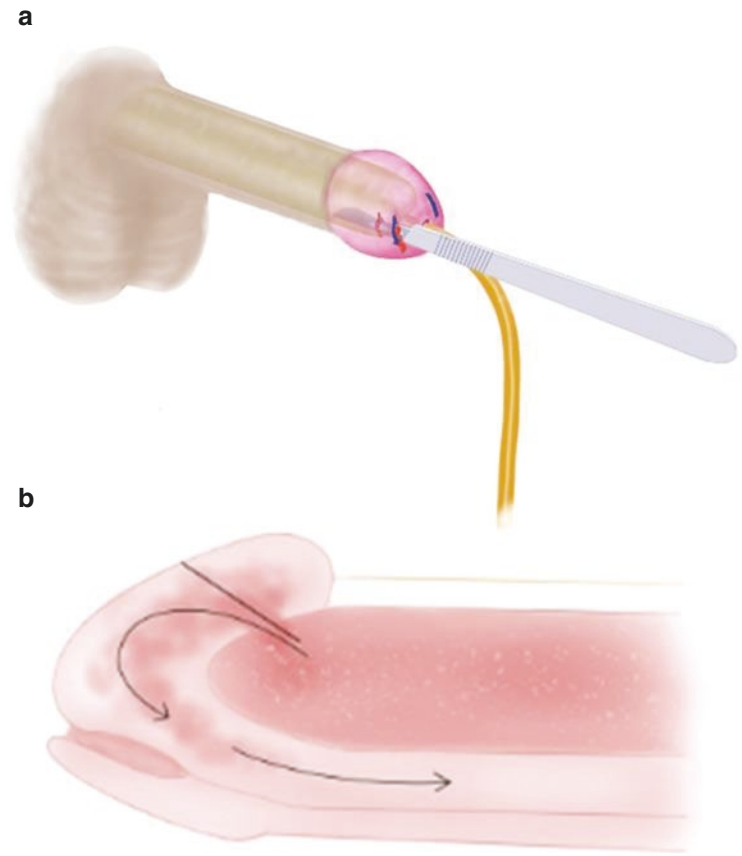


Fig. 42.8 Tunneling procedure, or Burnett snake procedure. **(a)** A 20–20 French straight sound is advanced through the transgranular corporal incision to the base of the penis; **(b)** this procedure establishes a large tunnel (black undulating line) through which to evacuate blood. This procedure essentially creates a proximal shunt through a distal incision

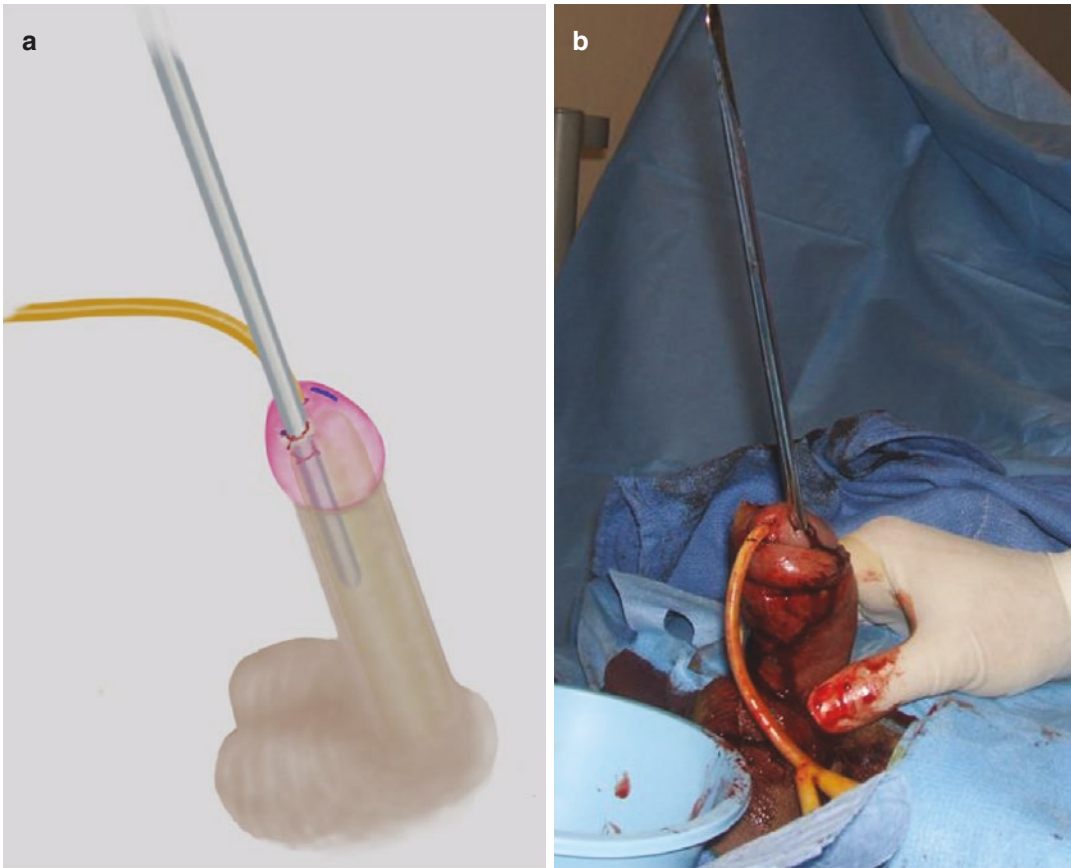
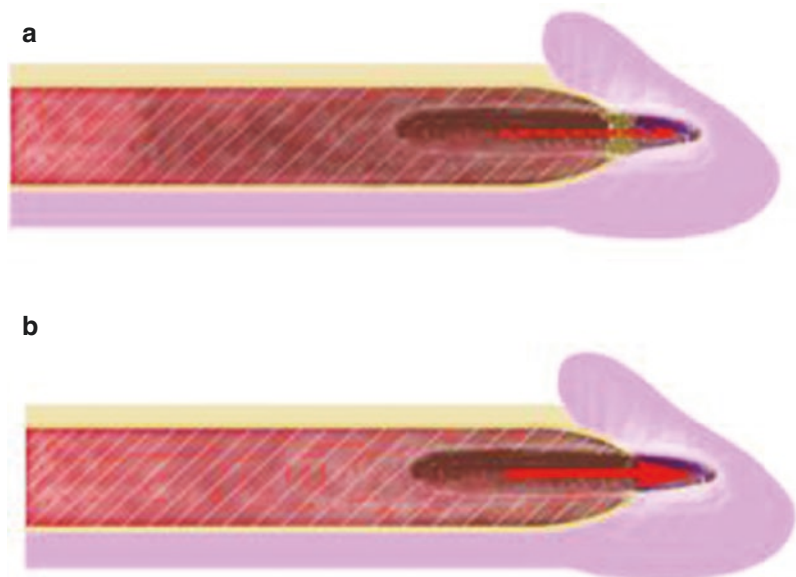


Fig. 42.9 (a) A dilator is passed through the left T-shunt incision, through the glans, and through the distal tip of the corpora cavernosa to dilate a pathway from the proximal corpus to the distal corpus. (b) Surgical image of the

dilation procedure using a straight metal sound through the T incision of the right glans, angling the dilator away from the urethra

Fig. 42.10 (a) After a distal shunt procedure, the blood is exposed to the collagen of the tunica albuginea leading to clot formation, thrombosis of the shunt, and failure to resolve the priapism. (b) With peri-procedural anticoagulation including pre-operative aspirin 325 mg po plus heparin 5000 units subcutaneously followed by post-operative daily aspirin 81mg plus clopidogrel 75 mg, shunt patency should be safeguarded against thrombosis, and the priapism should resolve



ischemic priapism during and after surgical shunt creation (Fig. 42.1).

42.8 Post-ischemic Hyperemia After Treatment of Ischemic Priapism

In ischemic priapism of more than 2 days duration, the penis may not detumescere completely after a successful shunting procedure. This is secondary to reactive hyperemia from prolonged tissue ischemia [14]. The patient may still have significant penile discomfort or pain, and the penis may still be semi-erect or erect on physical examination. Color duplex ultrasound is the preferred means of assessing response to shunting procedures as it provides a real-time measure of cavernosal blood flow. After a successful shunting procedure, penile corporal blood flow should be high. If flow is high in the cavernosal arteries, there is no need for additional surgical procedures, even if the patient has persistent penile pain and rigidity. This situation should be managed conservatively with pain medications and observation. If the patient truly has recurrent priapism, there will be no flow in the corporal arteries and an additional shunting procedure is indicated. If duplex penile ultrasound is not available, penile blood gas assessment may be utilized, although this method is not recommended. Blood gas is not as accurate as ultrasound as oxygen tension within the corpora may take several hours to change even after successful intervention.

42.9 Outcomes After Ischemic Priapism

In over 90% of ischemic priapisms lasting less than 24 hours, the condition can be managed by aspiration and injection of an alpha-agonist alone with recovery of spontaneous functional erections in 78–100% of patients. If over 24 hours in duration, some degree of ED can be expected in 56–100% of patients, with a longer duration of tumescence associated with a worse prognosis. In cases of priapism lasting longer than 5 days, the chance of recovery of erectile function is minimal [37].

42.10 Penile Prosthesis Placement

For patients with prolonged priapism and for those who do not respond to aspiration/injection of phenylephrine, immediate T-shunting [38] or penile MRI are both viable next steps. MRI is a good option to evaluate for smooth muscle necrosis if acute penile prosthesis placement is a consideration. If there is clinical evidence of significant smooth muscle necrosis (i.e. the patient has no response to phenylephrine injection or a contrast-enhanced penile MRI reveals significant necrosis), the patient may choose to delay all treatment while he considers his options as he is unlikely to recover erectile function. He may also choose for early penile prosthesis implantation.

Acute penile prosthesis implantation has been advocated for patients with an ischemic episode longer than 48 hours [39]. Studies suggest that immediate placement of a malleable penile prosthesis will preserve penile length with the implant acting like a tissue expander, allowing for replacement with an inflatable penile prosthesis at a later operation without significant difficulty [40]. This strategy may also lead to long-term cost-savings and decreased utilization of hospital resources [41]. Studies show that early implantation within 2 weeks of an ischemic priapism episode results in reduced corporal fibrosis [6] and fewer post-operative complications, such as erosion or infection. Infection rates for acute prosthesis placement are 6% and in delayed prosthesis placement 10% [42]. Delaying prosthesis placement for two or more months can also lead to severe penile fibrosis with subsequent penile shortening and narrowing with lower patient satisfaction rates [40]. In addition, previous shunt surgery is associated with increased risk of post-surgical infection and may increase the risk of distal or proximal corporal perforation at the time of penile prosthesis implantation [43, 44].

In our clinical experience with T-shunt plus perioperative anticoagulation, it is not uncommon for younger patients to recover varying degrees of erectile function, even when the duration of ischemic priapism exceeds 48 hours. As such, we rarely recommend early penile prosthesis placement for ischemic priapism patients. Granted, the patients may need oral PDE5 inhibitors or intracavernosal injection with vasoactive

agents to augment erectile function. Severe or complete erectile dysfunction after a priapism episode will be apparent within weeks of the priapism episode, and the decision for either inflatable or malleable penile prosthesis placement can be made at that time without significant penile fibrosis or loss of penile length and girth. In cases of refractory priapism where primary attempt at distal shunting has failed, it is possible that placement of a malleable prosthesis might lead to erosion of the device through the glans, depending on the size of the tunical defect. This would be a disaster for the patient. If the decision is made to proceed with prosthesis implantation after shunting, undersizing the malleable cylinders and suturing the malleable cylinders to the corpora may help to prevent distal migration of the implant while the shunt incision heals.

42.11 Prolonged Ischemic Priapism

Extraordinary circumstances may lead to an extremely delayed presentation of five or more days. If no attempt was made during that interval to re-establish penile blood flow, the chance of penile tissue viability is small and conservative management with pain medication is an option. However, the provided history may be unreliable or inaccurate, especially in patients who have psychiatric illness or a history of intoxication. There is the possibility that the priapism may have been “incomplete”, allowing for intermittent corporal arterial inflow. If the history provided is questionable, an attempt at needle aspiration and phenylephrine injection should be made even after such a prolonged time period. If ischemic blood rushes from the corpora and the erection resolves by 50% or more, T-shunt plus tunneling with periprocedural anticoagulation should be recommended for the best possible outcome with hopes of recovery of erectile function [7]. If blood trickles out slowly and the penis remains rigid despite aspiration and injection of an α -adrenergic agent, there is little hope that the patient will regain erectile function. In this scenario, pain management becomes the acute goal of therapy as the erectile tissue is not viable. The treatment options are pain

management alone, T-shunt plus tunneling with periprocedural anticoagulation, or MRI to confirm the clinical suspicion, and possibly acute penile prosthesis placement. Shunting surgery will not change the patient’s outcome but may speed resolution and control pain.

Thorough documentation of the pre-procedural discussion (anticipated outcomes, options, risks, benefits) followed by a detailed description of findings after any intervention are crucial in patients with prolonged ischemic priapism. Documentation is particularly important if the patient chooses for pain management alone.

42.12 T-Shunt and Corporal Tunneling

The T-shunt technique is easily learned as the anatomy is familiar to all urologists. The procedure can be performed at the bedside with local anesthesia or in the operating room with sedation plus local anesthesia or general anesthesia, depending on patient preference and surgeon comfort level. It is important to obtain written informed consent prior to performance of any procedure for priapism with emphasis placed on the risks of erectile dysfunction, change in penile sensation, glanular hypoesthesia, poor cosmesis of the surgical incision, and the risk of need for repeated procedures. With the T-Shunt, the risk of procedural complication is minimal as compared to other, more invasive surgical shunting options.

42.13 Description of T-Shunt Procedure and Tunneling

When a shunt is deemed necessary, a unilateral-T shunt is performed initially in most cases. To perform the procedure, the rigid distal tips of the corpora are palpated through the flaccid glans. Lidocaine 1% or bupivacaine 0.25% is injected subcutaneously into the glans penis and circumferentially in a ring block at the base of the penis. A 10-blade scalpel is positioned vertically at the glans penis lateral to the urethral meatus, inserted through the glans into the distal

tip of the corpus cavernosum, and advanced into the corpus until the hub of the blade is at skin level. The sharp edge of the blade is then rotated 90-degrees *laterally*, away from the urethra, and withdrawn through the glans (Fig. 42.7) [28]. Upon initial incision, there is typically an immediate return of copious thick, dark blood. The ischemic blood is manually expressed until the return of bright red blood, which suggests that the flow of oxygenated blood has been reestablished. This procedure should lead to immediate detumescence such that the contralateral distal corporal tip is no longer palpable. This occurs because the corpora are in continuity, joined via the incomplete midline septum. Next, the glans wound is closed with running locking absorbable suture, such as 4-0 or 5-0 chromic gut. Sutures should be placed superficially to avoid occluding the shunt, which may occur if the sutures are deeply placed. Interrupted sutures are not ideal as the glans has a rich blood supply and bleeding may persist after the procedure. The patient should then be observed for 15 minutes. If priapism recurs, the T-shunt procedure should be performed on the contralateral side after adequate additional anesthesia.

If the dark ischemic blood drains out *sluggishly* and the penis remains partially erect after expression of ischemic blood (due to severe edema of the intracavernous tissue), bilateral T-shunts should be performed in addition to transglanular intracorporal tunneling (Fig. 42.9) through the same incisions. A 20–22 French *straight* urethral dilator should be advanced slowly and parallel to the long axis of the penis, angled slightly laterally to minimize the risk of urethral injury. The sound should be advanced through the cavernous tissue to the base of the penile shaft. This procedure creates a large tunnel to allow more effective evacuation of old blood as well as passage of arterial blood to the distal penis to ensure patency of the shunt [34]. Finally, ischemic blood is manually expressed from the incision site(s) until bright-red blood is seen. Next, the incisions are closed with superficial running, locking 4-0 or 5-0 chromic gut.

After 15 minutes, the patient should be reassessed to ensure that priapism has resolved. For

episodes lasting longer than 36–48 hours, it is typical to observe post-ischemic hyperemia, a state in which the penile shaft is firm from local edema despite evacuation of trapped ischemic blood from the corpora. If the patient reports resolution of the constant dull ache within the penis and if the penis is sufficiently soft that the shaft indents 1–1.5 cm when compressed, the shunt is considered patent, and no further procedures are necessary. When in doubt, a color duplex ultrasound test (not intracavernous blood gases) should be performed as described above. The presence of flow in the cavernous artery indicates that the shunt is open and that tumescence is due to post-ischemic hyperemia and tissue edema -- no further intervention is needed. If the penis returns to a rigid state with no flow in the cavernous artery, the tunneling procedure should be repeated bilaterally through the same glanular incisions [45].

Using this algorithm, we have not had an incidence in which a “traditional” proximal shunting procedure was required as the corporal tunneling procedure essentially establishes as a proximal shunt. After completion of the procedure, the glans incisions are coated with antibiotic ointment twice daily for 5 days. No compressive dressing should be applied as these dressings tend to become progressively tighter and may obstruct the dorsal vein and/or corpus spongiosum, occluding the shunt. These dressings may also cause ischemia if applied too tightly [7]. Oral antiplatelet therapy should be continued for 5 days after the procedure.

42.14 Complications During and After Shunting Procedures

42.14.1 Distal Shunt Complications

Distal shunts may lead to a granular scar upon healing. The open distal shunt may also cause granular hypoesthesia or numbness due to damage to small branches of the distal cavernosal nerves, especially if a transverse skin incision is made, such as in Al-Ghorab procedure. The Al-Ghorab procedure may also result in urethrocutaneous fistula. Additionally, after creation of a

distal shunt, a larger-than-normal volume of arterial inflow into the corpora cavernosa is expected. This may last for hours to days and requires a large caliber shunt to move the large volume of inflow. If the shunt is small, the intracavernous pressure will rise and compress the surrounding tissue, obstructing the shunt and leading to recurrent priapism. A small shunt, such as created by an #11 blade scalpel (Ebbehøj shunt) or biopsy needle (Winter shunt) (Fig. 42.4), may close spontaneously due to the small caliber.

For creation of the T-shunt, it is recommended that a #10 blade knife be utilized and rotated 90° laterally as it is withdrawn to maximize the size of the shunt. When blood is exposed to the collagen of the incised tunica albuginea, the clotting cascade begins, and the shunt may clot if the patient is not on anticoagulation therapy prior to and after shunt creation. In our experience, in cases of refractory priapism where initial #10 blade T-shunt with tunneling failed, *repeated* #10-blade T-shunt with tunneling has been successful after the patient is fully anticoagulated (Fig. 42.1).

42.14.2 Proximal Shunt Complications

Proximal shunts drain blood from the proximal corpora to the proximal corpus spongiosum and urethral bulb either through a perineal incision (Quackles) or a penoscrotal (Sacher) incision. These shunts are unnecessarily complex to perform and carry increased procedural risks. Distal T-shunt with tunneling as described above (Fig. 42.9) has replaced the need to perform these shunts entirely. Anatomically, the sponge of the penile urethra is very thin in comparison to the sponge at the level of the bulbar urethra. If a shunt is created through a penoscrotal incision, the thin layer of spongiosal tissue present is inadequate to drain the cavernosum, and the thin nature of the sponge at this location escalates the risk of urethral injury. Cavernositis, caverno-urethral-cutaneous fistula, complete occlusion of the urethra, and profound cavernosal fibrosis may occur when a proximal shunt is placed too distally. As the distal T-shunt with tunneling is a

simple, highly efficacious technique, there is no need for proximal shunting procedures.

42.14.3 Venous Shunt Complications

Creation of a venous shunt is a complex surgery that requires expert microsurgical skill. The intricacy of this operation in addition to the unfamiliar nature of vascular surgery are major reasons why venous shunting procedures are no longer useful in management of ischemic priapism. In the case of the saphenous vein shunt (Greyhack), a second incision is required for dissection of the saphenous vein which increases perioperative and post-operative morbidity and raises the risk of post-operative wound complications. The path of the shunt is also meandering and may lead to poor outflow through the graft. It is also feasible that the patient may need the saphenous vein in the future for coronary artery bypass grafting surgery. The dorsal vein graft (Barry) is a more direct graft that does not require a second incision but does require expert microvascular surgical skill. Both of these procedures require degloving of the penis and a penile shaft incision, which carries the risks of wound healing complications and sensation loss, especially if the patient has had previous penile surgery. In the short term, it is also possible that the patient may occlude the graft with clot, in which case another procedure would be necessary. In the long term, it is possible that the graft might remain patent in which case a surgical procedure for ligation of the shunt would be required.

42.15 Post-operative Management

After any shunting procedure, it is important that the patient be continued on antiplatelet therapy with both aspirin 81 mg and clopidogrel 75 mg by mouth daily for 5 days (Fig. 42.1). This will ensure that the surgically created shunt remains patent allowing for continued circulation of blood from the corpus cavernosa to the corpus spongiosum. After 5 days, the post-ischemic hyperemia has resolved, and it is prudent to cease treatment with antiplatelet agents so that the shunt will

close promptly. If the shunt remains patent beyond the desired time frame, it is possible that the shunt will mature into a fistula that causes permanent erectile dysfunction. This situation may necessitate surgical intervention to close the fistula and restore erectile function.

42.15.1 Post-shunt Hyperemia

In many cases of ischemic priapism that last longer than 24 hours, post-shunt semi-tumescence persists even after a successful shunting procedure. This is the result of reactive hyperemia in response to the extended hypoxic, acidotic state. This condition is generally painless and will continue if the shunt remains open. Once the hyperemic state subsides, the normal minimal-flow state of the flaccid penis will not be able to keep the shunt open, leading to spontaneous closure in most cases.

42.16 Erectile Dysfunction After Shunt Procedure

The AUA guidelines estimate the rate of erectile dysfunction (ED) as <25% for distal shunts and 50% for proximal shunts [3]. In our experience, the T-shunt + perioperative anticoagulation has been very successful in reversing ischemic priapism and preserving erectile function in patients with priapism lasting fewer than 3 days. Even for patients who undergo multiple aspiration or surgical shunting procedures within 10 days of priapism onset, if the longest continuous priapism was less than 2 days, the prospect of regaining erectile function after treatment remains excellent with our approach.

42.17 Non-ischemic (High-Flow) Priapism

42.17.1 Pathogenesis of Non-ischemic Priapism

The etiology of non-ischemic priapism is typically perineal or penile trauma although it occasionally occurs after shunt procedures performed

for ischemic priapism [15, 46–48]. Following trauma, the initial vascular injury to the cavernosal artery or helicine arteries is exacerbated by nocturnal penile erections [8, 49]. Ultimately, a fistula forms between the artery and the sinusoidal spaces of the corpora cavernosa resulting in high-flow priapism. The ensuing unregulated arterial inflow causes a persistent, painless erection [50]. The venous drainage of the penis is not compromised, and the penile tissue is not ischemic thus the erection is not painful.

42.17.2 Management of Non-ischemic Priapism

We present a duration-based algorithm for non-ischemic priapism (Fig. 42.11). Early initial management is usually observation and penile compression as the condition may resolve spontaneously without intervention in approximately 62% of patients [3, 9]. Failure to resolve with conservative therapy prompts progression to non-invasive medical therapies. Though studies are small, androgen ablation has been shown to be an effective treatment for high flow priapism [8, 49]. In a study of seven men with non-ischemic priapism, treatment with leuprolide, bicalutamide, or fluconazole led to resolution of symptoms in six men after a treatment period ranging from 2 to 6 months [8]. Androgen blockade is thought to reduce nocturnal erections and accelerate restoration of vascular integrity after arterial trauma. If there is a damaged main cavernous artery, the current treatment algorithm for high flow priapism recommends a trial of androgen ablation prior to progression to embolization [49]. Occasionally, patients with prolonged non-ischemic priapism will develop distal corporal fibrosis which presents as distal penile flaccidity during erection [51]. Only approximately 60% of patients whose non-ischemic priapism resolves spontaneously will have full recovery of erectile function [52].

If observation or medical management fails or if the patient requests early treatment, selective arterial embolization utilizing absorbable material, such as autologous clot or gel foam, is the preferred treatment. Arterial embolization utilizing non-absorbable materials (ethanol, coils, n-butyl-2 cya-

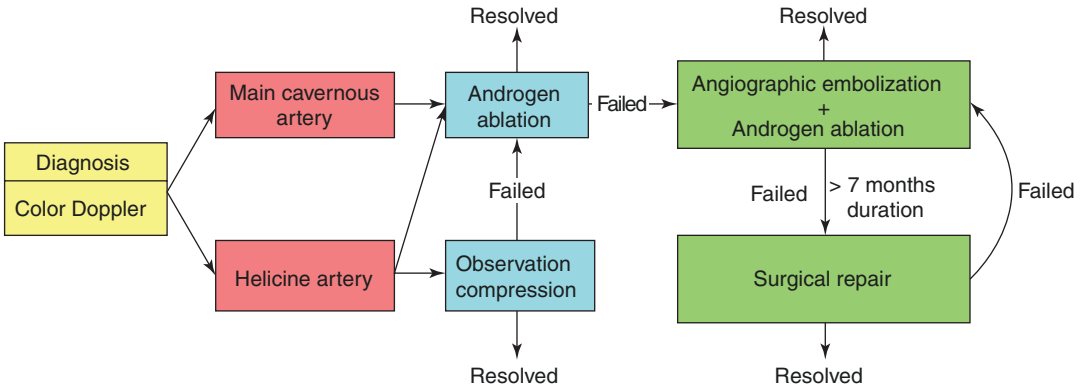


Fig. 42.11 Non-ischemic priapism management

noacrylate) may be considered but is less favorable due to an increased risk of erectile dysfunction (39% vs 5%) [3, 53, 54]. Both procedures have demonstrated similar efficacy with approximately 75% resolution rates. Computed tomographic angiography can be used to facilitate identification of the damaged vessel in three dimensions [55]. Percutaneous direct puncture embolization with n-butyl-2 cyanoacrylate has been used to successfully treat high flow priapism recurrence after failure of traditional arterial embolization [56].

Patients may be followed with Doppler ultrasounds to document the resolution of the fistulous connection. In men with non-ischemic priapism lasting longer than 6 months duration, a pseudocapsule may have developed and matured around the ruptured artery. If definitive therapy is contemplated more than 6 months after onset and a pseudocapsule is identified on ultrasound, suture ligation of the ruptured artery and its pseudocapsule using intraoperative duplex Doppler ultrasound guidance may be necessary. Surgical intervention may also be indicated in patients who fail arterial embolization.

42.18 Stuttering (Recurrent Ischemic) Priapism

42.18.1 Clinical Presentation of Stuttering Priapism

Stuttering priapism is defined as periodic episodes of prolonged erections that may lead to recurrent

ischemic priapism [3]. Episodes often occur during sleep or with sexual stimulation and may resolve spontaneously [15]. Because sickle cell disease patients are more commonly affected by priapism than non-sickle cell disease patients [57], the initial hypothesis was that priapism was caused by hemolysis, microvascular occlusion, and stasis due to the sickling of erythrocytes. Sickle cell patients with priapism have higher rates of hemolysis than sickle-cell men without priapism, as well as a higher red blood cell disaggregation threshold and lower red blood cell deformability, a pattern similarly found in sickle cell patients who experience leg ulcers and glomerulonephropathy [58]. More recently, animal models and clinical studies have implicated abnormal nitric oxide (NO) and cyclic guanosine monophosphate (cGMP) signaling and regulation in the pathogenesis of stuttering priapism [59–64].

42.18.2 Pathogenesis of Stuttering Priapism

Penile erection involves the generation of NO by neuronal nitric oxide synthase (nNOS) and endothelial nitric oxide synthase (eNOS) in response to sexual stimulation [60, 65]. NO diffuses into the cavernosal smooth muscle, causing smooth muscle relaxation and sinusoidal dilation leading to penile erection through downstream cGMP signaling [66]. cGMP is then hydrolyzed and inactivated by phosphodiesterase type 5 (PDE5) [67], leading to smooth muscle contrac-

tion and return of the penis to the flaccid state. Normal penile erection and detumescence require equilibrium of these signaling molecules, and dysregulation may result in either erectile dysfunction or priapism [65, 67, 68].

PDE5 dysregulation with resultant aberrant NO signaling appears to be an important cause of stuttering priapism [59]. Production of PDE5 is cGMP-dependent, and a basal decrease in the activity of cGMP leads to transcriptional down-regulation of PDE5, resulting in dysfunctional termination of the erectile response [64]. Low basal levels of cGMP are thought to stem from decreased bioavailability of NO. This may be secondary to endothelial damage with decreased eNOS activity and scavenging of NO by reactive oxygen species (ROS) or free hemoglobin released through hemolysis, particularly in sickle cell disease patients [68]. Supporting this theory, a priapism phenotype mouse model with increased erection frequency and increased intracavernosal pressure was created by transplanting sickle-phenotype bone-marrow 3–4 months prior to study [69]. This suggests that even subacute hemolysis may lead to priapism. Subacute hemolysis was associated with decreased activity of NOS, protein kinase G, and PDE5, and increased ROS compared to control mice not receiving sickle marrow transplantation.

Other signaling pathways involving adenosine, RhoA/Rock, and opiorphin may also be involved in the pathogenesis of priapism [70, 71]. Adenosine deaminase-deficient mice cannot convert adenosine to its inactive form and demonstrate a priapism phenotype [71]. In a mouse model of sickle cell disease, CD73, a molecule responsible for converting adenosine mononucleotides to adenosine, is upregulated compared to non-sickle cell mice [72]. Elevation of CD73 is also found in an *in-vitro* model of corporal hypoxia and is dependent on the hypoxia-induced upregulated expression of sialorphin, a murine homologue of opiorphin [72]. Corporal smooth muscle cells from a rat model of sickle cell disease demonstrate an upregulation in sialorphin in response to hypoxic conditions that leads to an increased expression of hypoxia inducible

factor-1 α (Hif-1 α) and the A2B adenosine receptor (A2Br) [73]. A2Br signaling reduces PDE5 gene expression in two mouse models of priapism (sickle cell disease mice and adenosine deaminase-deficient mice), and this is dependent on Hif-1 α [73].

42.18.3 Management of Stuttering Priapism

In addition to treating acute priapism episodes, the primary goal of pharmacologic management of recurrent ischemic priapism is to prevent additional episodes. Each additional episode increases the risk of progression to a prolonged major ischemic event [70]. The most common pharmacologic therapies for stuttering priapism involve hormone regulation, and more recently, PDE5 inhibitors [10, 74]. Select patients may also benefit from on-demand, self-administered intracavernosal injection of phenylephrine.

Reducing circulating testosterone (T) levels with agents such as GnRH agonists, 5- α reductase inhibitors, or ketoconazole is believed to improve stuttering priapism by limiting the erection-promoting effect of the androgen [4, 75, 76]. A retrospective review of 17 recurrent ischemic priapism patients treated with 6 months of ketoconazole reported that 94% of patients had resolution of priapism while on treatment and 29% had no recurrence after discontinuation of treatment [77]. However, hypogonadal men treated with topical T do not seem to experience higher rates of priapism [78], suggesting that other molecular targets may be more influential. While T deficiency and priapism are common in sickle cell disease patients, a cross-sectional study of 50 men with sickle cell disease was not able to demonstrate an association between T deficiency and priapism [79].

PDE5 inhibitor therapy represents a somewhat paradoxical approach to priapism management, as these drugs are typically utilized for patients with erectile dysfunction. However, in a mouse model of priapism, continuous low dosage PDE5 inhibitor therapy normalized dysregulated PDE5

levels and reduced the occurrence of priapism episodes [62]. Sustained NO releasing compounds have also been shown to normalize activated eNOS and other biochemical elements of erection signaling in mouse models of priapism [61]. In a rat model of ischemic priapism, treatment with pentoxifylline, a non-selective PDE inhibitor, reduced collagen density in the corpus cavernosum, possibly through mechanisms relating to inhibition of TGF- β [80]. The PDE5 inhibitor, sildenafil, may provide a vasculo-protective effect through increased expression of eNOS and inhibition of NADPH oxidase, which is the enzyme responsible for the production of the free radical superoxide [63]. In a mouse model of subacute priapism, daily administration of sildenafil for 3 weeks increased NOS and PDE5 activity, decreased ROS, and lowered intra-cavernous pressure during erection compared to the untreated sub-acute hemolysis mice [69]. The therapeutic effect of long-term, low-dose hydroxyurea to treat priapism in sickle cell patients may also involve the NO signaling pathway [81].

In a retrospective evaluation of 7 patients with recurrent ischemic priapism, daily sildenafil improved episodes of stuttering priapism [74]. A double-blinded, placebo-controlled randomized trial of 13 sickle cell disease patients with recurrent ischemic priapism was conducted with an 8-week blinded phase followed by an 8-week open-label phase where all patients received treatment with daily sildenafil 50 mg. The primary outcome was a 50% reduction in the number of weekly priapism episodes. No difference was found between the sildenafil group and placebo group during the blinded phase of the study. During the open-label phase of the study after 5 patients were lost to follow-up, 5 of 8 patients by intention to treat analysis and 2 of 3 patients by per-protocol analysis experienced a 50% reduction in weekly priapism episodes [10]. Though the results of this RCT were equivocal, current expert recommendation for patients with stuttering priapism is treatment with sildenafil 50 mg daily taken at a time completely unassociated with sexual activity [70]. Higher doses may

increase the risk of vaso-occlusive crisis in sickle cell disease patients [82].

42.18.4 Future Therapies for Stuttering Priapism: Chemodenervation with Botulinum Toxin

In clinical practice, if patients cannot tolerate antiandrogen therapy, there are no known prevention strategies for stuttering priapism currently available and FDA approved. Botulinum toxin A may serve as a means of chemodenervation and preventative therapy for stuttering priapism in patients who are refractory or intolerant to conventional treatments. Physiologically, botulinum toxin A should cause a decrease in the release of acetylcholine (ACh) and nitric oxide (NO), producing a reversible inhibitory effect on penile erection. In our pilot animal study, it was confirmed that botulinum toxin suppresses penile erection in rats. Histologic studies revealed a decrease of nNOS (+) nerves within the corpus cavernosum. However, the therapeutic range, duration of effect, and time and degree of functional recovery, as well as complete understanding of molecular mechanisms, remain unknown, and further studies are planned.

The importance of parasympathetic nerves for producing penile erection is well established [65]. In addition to the NO/cGMP pathway in the penis, ACh is a very important molecule in this biological process. The penile tissues receive a rich cholinergic innervation as demonstrated by histochemistry (vesicular ACh transporter staining) and immunohistochemistry. ACh released from these nerves acts on muscarinic receptors distributed on cavernosal smooth muscle and endothelium and induces smooth muscle relaxation.

Most nitrergic nerves are cholinergic, and colocalization of nNOS and choline acetyl transferase (ChAT) has been demonstrated in cholinergic nerve terminals. During penile erection, nitric oxide (NO) is released from two nitric oxide synthases: neuronal (nNOS) and endothelial (eNOS).

Stimulation of parasympathetic nerves releases ACh as well as NO from nNOS. ACh and shear stress both can stimulate NO release from eNOS in the endothelium. It has been postulated that NO from nNOS initiates erection and NO from eNOS maintains erection.

Since its first clinical application, extensive evidence has demonstrated that botulinum toxin A inhibits the function of cholinergic nerves by blocking release of ACh, which in turn decreases release of NO from eNOS. In addition, it is likely that botulinum toxin A also inhibits NO release from nNOS. A decrease of NO release impairs penile erection. Thus, we propose that botulinum toxin A can be used to prevent stuttering priapism for a period of time until the chemodenervation effect terminates. A decrease in nNOS in submandibular and parotid glands has been reported after local injection of botulinum toxin A [83–86]. However, the effect on of botulinum toxin A on penile nNOS has not been studied as thoroughly. To evaluate the effect of botulinum toxin A on penile erection, we injected botulinum toxin into the corpus cavernosa of adult male rats and then measured the maximum intracavernous pressure (ICP). ICP was significantly reduced in the treated rats 3 weeks after botulinum toxin A injection. By 12 weeks, most rats recovered normal ICP (unpublished data).

The light chain of Botulinum toxins targets consensus sites on the SNARE (Soluble NSF attACHment protein receptor) superfamily of synaptic proteins, including SNAP-25 (synaptosomal-associated protein 25) and VAMP (vesicle associated membrane protein). SNARE cleavage prevents vesicle fusion and ACh release. It has been postulated that atrophy may occur at the nerve terminals entered by botulinum toxins. After 2–4 weeks, new nerve fibers sprout out to regenerate the damaged nerve. However, no research has yet clarified this series of events. Results of our preliminary unpublished experiment demonstrated a decrease of vesicular acetylcholine transporter (VACHT)(+) nerve terminals in both cavernous sinusoids and penile dorsal areas. Interestingly, nNOS and PDE5, two critical molecules in the

NOS/NO/cGMP pathway, were also down regulated in botulinum toxin A-treated penile tissue, while the expression of smooth muscle actin was not affected.

To date, we have utilized serial penile botulinum toxin A injections in one young adult patient with success in reducing his recurrent ischemic priapism episodes. The patient has a history of severe autism and is unable to live independently. He has a history of over 43 emergency room and doctor's office visits for priapism. Antiandrogen therapy was attempted, but he could not tolerate the side effects from prolonged therapy. To perform the injection, we apply a penile clamp or tourniquet at the base of penis to prevent systemic side effects. Botulinum toxin A (100 units in 10 ml of injectable saline) is injected into the corpus cavernosum at 3 or 9 o'clock using a 21-gauge scalp vein needle. The tourniquet is left in place for 10 minutes and then removed. Three injections were given at monthly intervals. Since his treatment, he has had reportedly normal nocturnal erections and no episodes of priapism for 36 months. The exact mechanisms of botulinum toxin in inhibition of penile erection and the series of biological events that occurs after injection remain to be clearly elucidated. Additional research into prevention strategies for stuttering priapism are needed.

42.19 Conclusions

The detailed molecular mechanisms of ischemic and stuttering priapism remain unknown but effective treatment options do exist. We recommend that urologists follow the proposed duration-based algorithms for the treatment for priapism, and we hope that these algorithms help to simplify treatment for this difficult condition. As scientific discovery progresses, new targets for pharmacologic intervention will be identified, therapeutics will improve, and surgical interventions will evolve. Early diagnosis, rapid treatment, and prevention of additional episodes remain the current goals of therapy.

Key Summary Points

- Priapism is defined as a prolonged penile erection for more than 4 hours unrelated to sexual stimulation.
- Ischemic (low-flow or veno-occlusive) priapism is a urologic emergency and presents as penile corporal rigidity associated with penile pain related to hypoxia, hypercapnia, acidosis, and glucopenia. The glans penis typically remains flaccid.
- Treatment of ischemic priapism depends on the duration of the priapism. If the duration is less than 24 hours, aspiration and irrigation with a diluted alpha-adrenergic sympathomimetic agent is preferred. If the duration is 1–2 days, anticoagulation and T-shunt are recommended. If the duration is between 2 and 5 days, anticoagulation, T-shunt, and tunneling are recommended.
- Proximal shunting procedures are not recommended. Distal shunting procedures in combination with pre-operative and post-operative antiplatelet therapy and tunneling procedures have replaced proximal shunting procedures.
- Post-ischemic hyperemia may masquerade as recurrent priapism after shunting procedures. Penile duplex ultrasound (not penile blood gas) is recommended to confirm this condition prior to repeated shunting, which may be unnecessary.
- If ischemic priapism lasts longer than 5 days continuously without intervention, contrasted penile MRI may be considered to evaluate for smooth muscle necrosis and to inform further treatment decisions.
- Stuttering (recurrent) priapism may be treated with once daily dosing of a PDE5I taken at a time unrelated to sexual stimulation, androgen ablation, or on-demand, self-administered intracav-

ernal injection of phenylephrine (in select, reliable patients who cannot tolerate other treatments).

- Non-ischemic (high-flow) priapism presents as a persistent, nontender penile erection with the diagnosis based on history, physical exam, and color Doppler ultrasound.
- If involving the helicine arteries, non-ischemic priapism may be observed or treated with androgen ablation therapy. If involving the main cavernous arteries, non-ischemic priapism may be treated with several months of androgen ablation; if medical therapy fails, selective arterial embolization with androgen ablation is the next option.
- Guidelines for the treatment of priapism have been published by both the American Urological Association and the European Association of Urology. These guidelines are based on expert consensus and a review of the available scientific and clinical literature.

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Surgical Treatment of Erectile Dysfunction: Historical Perspective and Overview

43

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43.1 Historical Perspective

The first modern report of a surgical treatment for erectile dysfunction (ED) dates back to 1873 when Francesco Parona from Italy first reported the sclerosis of the dorsal penile vein with hypertonic saline in a young man [1]. In the late 18th and early 19th centuries other reports followed depicting deep dorsal vein ligation or sclerotherapy [2]. Later on, Oswald Lowsley combined deep dorsal vein ligation with plication of the ischiocavernosus muscles [3]. However, results, such as today, were erratic and short-lived [4–6]. In 1936, Nikolai Bogoraz was the first to report the utilization of rib cartilage during penile reconstructive surgery in order to facilitate erection [7]. The report of this technique sparked a revolution and Bogoraz was soon followed-up by others authors such as Frumkin, Bergman and Henninger [8–10]. Nonetheless, poor long-term results due to rib cartilage reabsorption played

down the early success of this technique and led to its almost complete abandonment. In 1950 Peter Scardino performed the first single and unpaired rigid penile prosthesis made of acrylic but never published his work [10]. At the time this prosthesis was inserted under the penile skin dorsally and soon other authors such as Goodwin followed on his technique [11]. However, the initial enthusiasm was short-lived as the lack of firm proximal support, difficulty in penetration and poor sexual activity derailed its utilization by others.

One of the most important milestones in the surgical treatment of erectile dysfunction occurred in 1966 when Beheri from Egypt reported a case-series of over 700 men who had undergone a paired implantation of rigid penile prosthesis made of polyethylene inside the corpora cavernosa paving the way for intracavernosal insertion [12]. However, satisfaction was also limited due to the rigidity of the material used as well as other complications such as extrusion and infection and also the fact that Beheri was a plastic surgeon and published in plastic surgery journals did not draw attention from the urology community [8, 10].

Another important milestone occurred outside the field of medicine when the National Aeronautics and Space Administration developed a high-grade silicone as part of the space program that was subsequently used until today in penile prosthesis. In 1973 when Brantley

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Scott, who would later help found American Medical Systems (AMS), first presented the three-piece inflatable paired penile prosthesis and would later be named “AMS 700” a name which has been carried over until today [13]. A year later in 1974 the Small-Carrion prosthesis was also introduced by Mentor which would later be bought by Coloplast [14]. It was a paired semi-rigid penile prosthesis which became widely used and was the most implanted penile prosthesis during the 70s and 80s. In 1983, Mentor also introduced a competing three-piece inflatable penile prosthesis. Mentor main difference was the use of different materials like polyurethane and later Mentor’s patented Bioflex® material [15, 16].

While the focus of attention was on the development of penile prosthesis in the 70s and 80s, Vaclav Michal from Czech Republic in 1973 first introduced penile revascularization (Michal I and II procedures), as a non-pharmacological and non-device-related reconstructive surgical strategy for men with erectile dysfunction [17–19]. These technique used microvascular arterial bypass surgical techniques not well known at the time by urologists. Although with more limited indications, contemporary penile revascularization still stands today as an attempt to cure arteriogenic erectile dysfunction in young men with arterial pathology secondary to blunt pelvic, perineal or penile trauma [20].

Since the 90s penile prosthesis have been the mainstay surgical treatment of erectile dysfunction with both AMS and Mentor/Coloplast continually improving existing models or introducing new ones. Two-piece inflatable penile prosthesis have been introduced by both AMS and Mentor. In 2000, AMS introduced the InhibiZone™ coating [21], composed of minocycline and rifampin, in order to reduce infection, while Mentor responded with the Titan® in 2002 [22], which has cylinders coated with a hydrophilic substance that decreases bacterial adherence and can absorb and release antibiotics. Pumps have also been improved as in 2000 Mentor introduced the lock-out valve in order to prevent auto-inflation [23] while AMS later in 2013 responded with the Momentary Squeeze preventing both unintentional

inflation/deflation [24]. Reservoir design has also been subject to new developments which allowed ectopic reservoir placement as AMS introduced the Conceal® reservoir in 2006 and more recently, Coloplast unveiled the Cloverleaf® reservoir.

AMS has been bought by Boston Scientific in 2015 and new brands like Promedon, Zephyr Surgical Implants(ZSI) and Rigicon® appeared in the market. Recently, in 2012 ZSI has introduced the first inflatable and semi-rigid models specifically for female-to-male transgender surgery.

43.2 Penile Prosthesis

In the last four decades, penile prosthesis implantation has been the standard for surgical treatment of erectile dysfunction. In the following subchapter, surgical technique, intra-operative complications, post-operative complications and outcomes will be discussed.

43.2.1 Types of Penile Prosthesis

There are two major type of penile prosthesis, the semirigid prosthesis and the inflatable prosthesis. Although the purpose of both models is to reestablish erection and penetrative ability in erectile dysfunction patients, there are noticeable differences in flaccidity, cosmetic results and complications between these two major types.

Semirigid prosthesis are usually paired solid cylinders which can be further subdivided in malleable or positional accordingly to the mechanisms that allows positional change. Individual cylinders can be made in different lengths and/or girths and some models can be trimmed or added rear tip extensors in order to achieve the ideal length. These prosthesis are known for being much less expensive, easy-to-use by patients, easy to implant by surgeons and with a much lower mechanical failure rate. However, these prosthesis simulate a permanent erection that patients find it hard and difficult to conceal, while not allowing for neither girth or length expansion

has some inflatable prothesis allow. Moreover, even though mechanical failures are very low over time, their permanent stiffness can loosen up the tunica albuginea leading to poor quality of erection and decreased patient satisfaction as well as distal erosion.

Currently, there are a number of models available from several brands being the AMS 600 Spectra and the Coloplast Genesis the most well known and used worldwide.

Inflatable prosthesis are characterized by the ability to allow flaccidity when not in use and expansion with pump activation. These can be subdivided in two- and three-piece prothesis according to the number of components. Three-piece components are constituted by cylinders, pump and reservoir while in two-piece prothesis the omitted third component, usually the reservoir, is incorporated in the rear tip of cylinders. These prosthesis mimic more closely a natural erection, yet it comes at the cost of more expense, more complexity and higher rates of mechanical complications. Moreover, they also require more patient or partner dexterity and comprehension in order to function.

Cylinders are also sold marketed on different sizes of length and girth. These can usually be adjusted with rear extenders. These cylinders allow girth expansion and some models, like the AMS 700 LGX, even allow length expansion.

Pumps from different manufactures may present specific characteristics. AMS has introduced the Momentary Squeeze which requires only a quick squeeze in order to deflate the cylinders. Coloplast has introduced the lock-out valve to prevent auto-inflation and also the one-touch release in order to facilitate and speed cylinder deflation [23].

Reservoirs are also manufactured in different volumes according to cylinder size and manufacture specifications. New design concepts have been introduced in the last decade in order to allow ectopic reservoir placement in patients with previous history of inguinal and/or pelvic surgery. Reservoirs like the Conceal® from AMS and the Cloverleaf® from Coloplast allow safe ectopic placement between the transversalis fascia and rectus abdominis muscle.

43.2.1.1 Pre-operative Patient Evaluation

Although penile prothesis implantation is associated with the highest reported patient satisfaction and is highly effective in treating erectile dysfunction, it is an irreversible procedure with known intra-operative and post-operative complications that range from mild to life-threatening such as penile prothesis infection. All patients should undergo medical and psychiatric evaluation [25] prior to penile prothesis implantation and should also be educated and informed about the various types and models of penile prothesis, and their intrinsic characteristics and disparities. Providing images and videos of the cosmetic and functional end-result of an implanted penile prothesis as well as allowing the patient to handle a sample of the different models can help ease the patient and partner informed decision and consent [26]. A penile doppler ultrasound with an vasoactive agent should also be performed for both medical and legal reasons as it can confirm irreversible organic etiology. During the physical examination stretched penile length should also be documented and shown to the patient in order to avoid unrealistic expectations, patient dissatisfaction and legal litigation [27].

There are few absolute contra-indication for penile prothesis implantation, namely the inability to underwent anesthesia, untreated or untreatable blood dyscrasia known, known untreated active infection or known hypersensitivity or allergy to prothesis materials. Other potential or relative contra-indications have also been proposed, such as potentially reversible erectile dysfunction, poor compliance with treatment, inability to follow instructions or spinal cord injury. These often do not impede surgery but require extra assurance and ponderation when deciding as potential complications can be more frequent.

43.2.1.2 Pre-operative Care

Penile prothesis implantation, either semi-rigid or inflatable, can be performed under general, spinal and even local anesthesia according to patient condition and surgical team preference. The patient should be placed in a supine position

on the operative table. The genitals are shaved and scrubbed with chlorhexidine soap immediately before the incision. Two intravenous broad-spectrum antibiotics should also be administered before the incision and the skin should be prepped with an alcohol-based solution. There is evidence that alcohol-based chlorhexidine solution is better than povidone-iodine in preventing surgical wound site infection [28]. A surgical incision drape should be also placed in order to decrease undesired skin contact.

43.2.1.3 Surgical Technique

Penile prostheses can be implanted using a penoscrotal, infrapubic or sub coronal approach. Our group favors a single-incision penoscrotal approach for both semi-rigid and inflatable approaches. A Foley catheter is placed, capped and a Scott retractor is secured along the base of the penis. Blunt yellow hooks should be used as they minimize damage to prosthesis or surgical gloves. A two-centimeters median skin incision is performed inferior to the penoscrotal junction along the median raphe. Scrotal fat is swept inferiorly and secured with the help of hook retractors. Following exposure of the Buck fascia an incision is made bilaterally to expose the corpora cavernosa. A vertical corporotomy is made bilaterally. Corporotomy length varies depending on type and model of prosthesis but often a 1.5 cm incision is made for inflatable while a larger incision is usually preferred for semi-rigid ones. One or two rows, according to corporotomy length, of 2–0 Vicryl™ should then be placed and needles can be cut and removed from the surgical field. Care should be taken on corporotomy placement in three-piece inflatable prosthesis as more proximal corporotomy can lead to unwanted tubing awareness.

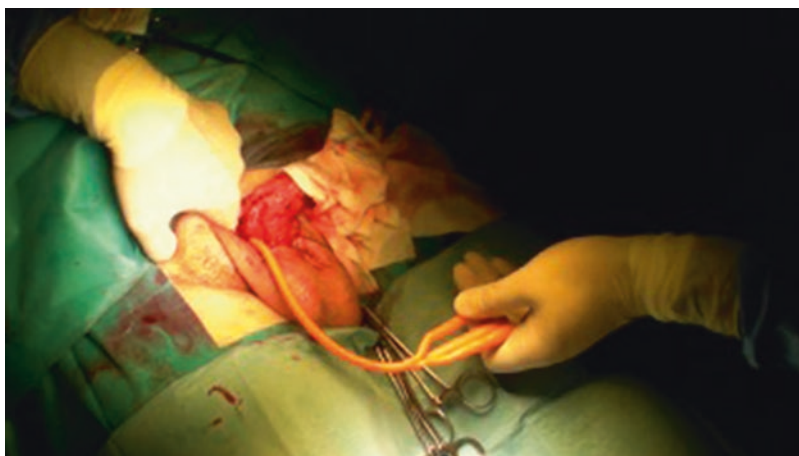
A Metzenbaum scissor is then used to initiate the tunneling of the corpora cavernosa. The curvature of the scissors should face away from the midline and its tip should be next to the lateral tunica albuginea. Constant traction in the penis is the key to ensure correct tunneling of the corpora while avoiding crossing over. Corporal dilatation can be performed using Brook's or Hegar dilators if needed as in primary implantation cases dil-

ation may be not necessary. The surgeon must be aware that most of intra-operative complications occur during this step. After finishing corporal dilation two dilators should be placed proximally and distally in order to check for cross-over to proximal or distal tunica albuginea perforation, the so called "field goal test". A "distal fluid challenge test" can also be performed. A Furlow inserter is used to measure proximal and distal corporal length. After determining the total corporal length, the appropriate cylinder size is selected.

If implantation of a three-piece inflatable prosthesis was chosen, the external inguinal ring should be identified using blunt dissection while a Mayo scissor is used to gently puncture the transversalis fascia and allow access to the retro-pubic space. A Deaver retractor can help ensure good exposition. A Foley catheter balloon is inserted into the retropubic space and inflated with 80–100 mL of normal saline (Tomada's maneuver, Fig. 43.1). If it is difficult or not possible to place the reservoir through the same incision, it can be placed by counter-incision or ectopically in a sub muscular location. Previous pelvic surgery should defer the surgeon from placing the reservoir through a single incision or retropubically. Although rare, the most severe complications associated with penile prosthesis implantation, such as bowel or vascular perforation, can happen during this step therefore extreme care should be taken.

By this time all previously used instruments are considered contaminated and removed from the surgical field, surgical gloves are replaced, and a new skin drape is placed. Following the "no touch" technique principles may further decrease infection rates [29]. In case of two- or three-piece inflatable prosthesis tubing, reservoir and pump are flushed in order to completely remove all air. Tubing should then be closed with two protected Kelly clamps in each extremity. Cylinders are then brought to field and positioned distally in the dilated corpora cavernosa using a Furlow insertion tool with a Keith needle while proximally a pusher can be used if needed. The Foley catheter balloon previously placed in the retropubic space is deflated and replaced by the reservoir, which is

Fig. 43.1 Tomada's manoeuvre. After blunt incision of the external inguinal ring, a urethral catheter balloon is placed in the prepubic space and inflated to 80–100 mL to create space for the reservoir



then filled with the appropriate volume of isotonic normal saline according to cylinder size and manufacturer specifications. After connecting the fluid reservoir and the cylinders to the pump, the device is inflated and deflated to ensure functionality and good cosmetic outcome. The pump is then placed in a subdartos pouch. Previously placed Vicryl™ sutures are used to close the corporotomy as in a mattress suture. A closed suction drain can be placed at this time if there are concerns with hemostasis. There is not a general agreement on drain placement but close suction drains do not increase infection rate while preventing hematoma formation [30, 31]. Dartos fascia and Buck's fascia are closed using 3–0 Vicryl™, and the incision is closed with a running suture of 4–0 Vicryl rapid™. In case of inflatable prosthesis the cylinders are left partially filled in order to ensure hemostasis. After the skin is closed, the patient is placed in a frog-leg position and his penis and scrotum are wrapped with a compressive scrotal dressing. Alternatively, a mummy wrap can be performed.

43.2.1.4 Intra-operative Complications

Ensuring correct surgical technique is essential in preventing and reducing intra-operative, and even post-operative, complications. However, complications do and will happen and the surgeon should be familiar on how to solve them.

Distal perforation or crossover can happen during tunneling and dilation and it is preferable to identify and correct it during dilation than after

cylinder placement or post-operatively. This complication can be recognized when asymmetry is identified or a metal rubbing is felt between corporal dilators. The same holds true for proximal perforation. If the surgeon suspects urethral perforation and he/she is not comfortable with repairing, surgery can be terminated and prosthesis implantation can be safely rescheduled 6 weeks after, although ensuing corpora fibrosis can add further difficulty and lead to additional penile length loss.

To correct a distal perforation distal perforation a subcoronal incision is performed and the distal tunica albuginea should be incised in order to search for the medial tunical defect. The defect can be closed with separate PDS stitches. The tunica albuginea incision is then closed using PDS. Alternatively tunneling and dilation can be performed again avoiding the false passage, and if successful, the cylinder can then be safely placed.

Proximal perforation is less dangerous as urethral injury is uncommon and can also be identified after the “field goal test”. Reparation can be performed either through distal tip extensor anchoring to the proximal corpora cavernosa or input tubing fixation to the corporotomy in the case of two- or three-piece inflatable prosthesis.

43.2.1.5 Post-operative Care

Patients can be safely discharged on the same or the next day. Urethral catheter and penoscrotal dressing can be safely removed in the next day and cylinders can be deflated in case of inflatable

prosthesis. Patients are instructed to wear tight underwear and preferably position the penis upward in order to mold capsule formation. Even though the efficacy of post-operative antibiotic therapy has not been demonstrated and remains controversial, the majority of implanters still prescribe antibiotics favoring quinolone, 1 week duration [32]. Patients are taught on how to operate the device 4–6 weeks after the surgery after edema and scarring resolution. Follow-up visits are scheduled for 3, 6 and 12 months and thereafter yearly in order to assess complications, device functioning and patient satisfaction.

43.2.1.6 Post-operative Results

Although invasive and irreversible, implantation of a penile prosthesis provides long-term cure of erectile dysfunction with the highest patient and partner-reported satisfaction rates. Results have improved in the last decades possibly as a result of improved peri-operative care, surgical technique as well as improvement of penile prosthesis material, design and mechanics. Patient-reported satisfaction seems to steadily increase during the first 6 post-operative months as pain and edema subside and patients improve prosthesis handling. High satisfaction results seem to be common to all main device manufactures [33, 34].

Factors of postoperative dissatisfaction have been studied and loss of penile length has been reported as the most common complaint [27, 35]. Obesity and Peyronie's disease are also known negative predictors [35], although probably part as a result of loss of penile length. Intra-operative strategies to preserve or increase penile length have been introduced in the last decade notably for patients with erectile dysfunction and Peyronie's disease [36–41]. Manufactures have also developed models, like the AMS 700 LGX, which also feature length expansion to more closely mimic a natural erection [40].

43.2.1.7 Post-operative Complications

Infection

Penile prosthesis infection is a serious complication which often requires prosthesis explantation or at least a salvage attempt. Reports suggest that

most infection were caused by relatively innocuous skin bacteria which adhere to the prosthesis at the time of implantation creating a biofilm around the prosthesis that can not be completely eradicated with antibiotherapy. Strategies like antibiotic-coated prosthesis, peri-operative prophylactic antibiotherapy as well as operative techniques such as the “no touch” approach have allowed a decrease in the infection rates to around 0.46–1.4% in the last couple decades [29, 42]. Although the introduction of antibiotic-coated prosthesis, such as the InhibiZone coating from AMS, effectively prevented infection from relatively innocuous skin bacteria [43]. However, there has been a shift from late-appearing less virulent bacteria to earlier infection caused by more virulent bacteria such as *Enterococcus faecalis* and *Pseudomonas aeruginosa* [44, 45].

Recently a retrospective study has shown that although around two thirds and one third of penile prosthesis infection are caused by gram-positive and gram-negative bacteria, respectively, there are still a significant number of infections caused by fungus, anaerobic bacteria and methicillin-resistant *Staphylococcus aureus* which are not usually covered by currently recommended peri-operative prophylactic antibiotherapy [45].

Infection presentation can vary in severity and timeline. It can range from localized pain and swelling to erythema, abscess or tissue necrosis with systemic signs such as fever and elevated white blood cell count. Usually pain and edema are expected during the first two postoperative weeks and lack of improvement or aggravation of symptoms by the third week usually suggest infection. Infection can also manifest months and even years later. Imaging studies are usually unhelpful and the decision has to be made based only on clinical findings.

The surgeon should defer from prescribing antibiotherapy as when clinical signs present it is useless strategy as it can not eradicate biofilm already formed. Instead penile prosthesis explantation or a salvage attempted are indicated at the time of infection diagnosis. Penile prosthesis explantation implies the removal of all the

device parts as well as all the non absorbable material used, such as sutures or grafts used for concomitant penile curvature correction. Usually after infection is treated and inflammatory reaction is resolved, a waiting period ensues if secondary penile prosthesis implantation is desired. However, prosthesis explantation often leads to severe fibrosis of the corpora cavernosa often complicating secondary implantation and causing loss of penile length that can lead to patient dissatisfaction. Also, secondary implantation is known for having a higher infection rates and less success rate even for experienced surgeons [46].

Salvage protocols, being Mulcahy one of the most known, consist of penile prosthesis replacement after profuse wound cleansing with several antiseptic solutions [47, 48]. These procedures have been introduced nearly two decades ago in order to prevent loss of penile length and in properly select patients salvage can have success rates up to 84%. Replacement of a inflatable with a semi-rigid prosthesis can also be an alternative as later the semi-rigid prosthesis can be safely replaced with an inflatable in case of no reinfection. Even though there are no absolute criteria on who is eligible for early salvage it is commonly agreed that patients with an early detected non purulent infection are optimal candidates while a necrotic infection, infection with *Enterococcus* spp., uncontrolled diabetes mellitus or cylinder extrusion through the urethra salvage are contra-indications [49, 50].

Prevention is key and adherence to aforementioned strategies such as use of peri-operative intravenous antibiotics, antibiotic-coated or antibiotic irrigated prosthesis and a clean surgical technique with adoption of “no touch” principals or similar can decrease post-operative infections.

Mechanical Failure

With manufacturer improvement of penile prosthesis design and material, mechanical failure is becoming less and less common [8, 10, 26]. Wilson's long term results of primary implants have shown that penile prosthesis are durable in time with 79.4% and 71.2% of penile

prosthesis fully functioning at 10 and 15 years, respectively [51]. However, mechanical failure is still the leading cause of revision. Most common causes of mechanical failure are leaks in the system whether in the tubings, connections or even breaks in the cylinders silicon. Mechanical failure often implies device replacement, but it is not agreed if all the componentes need to be replaced, specially the reservoir, or only the damaged ones. Recent evidence and consensus seem to suggest that complete replacement might decrease infection and mechanical failure rates in relation to limited replacement [52, 53]. Cylinder aneurism (Fig. 43.2) and pump malfunction are complications that can also occur [54].

Erosion

Erosion is usually a long-term complication, often occurring months or years after implantation. It is the second most common cause of revision surgery [46]. Oversized semi-rigid cylinders are known for distal extrusion often evolving the urethra (Fig. 43.3). Other locations are also possible often as a result of slow developing chronic infection. Erosion is not amenable to salvage procedures and requires complete removal of all the penile prosthesis components. Often in semi-rigid prosthesis erosion is unilateral and only that cylinder needs to be removed. This strategy leaves one cylinder in place which is often sufficient to allow intercourse. If the urethra is involved urethral catheter should be left in place for 1–2 weeks to allow healing. As for prosthesis infection, a waiting period is required before a new implantation is tried. Severe fibrosis of the corpora cavernosa during the waiting period can also impair results, namely penile length and consequently patient satisfaction.

Isolated pump or tubing erosion (Fig. 43.4), although rare, has also been described in the past, usually as a consequence of infection [55]. Reservoir erosion is also a known complication of retropubic reservoir placement for inflatable prosthesis, but it is also a rare complication occurring in 0.4% of cases. It has been described erosion into the bladder, bowel, ileal conduit and neobladder in the past [56–60]. Treatment usually

Fig. 43.2 Cylinder aneurism



Fig. 43.3 Bilateral distal cylinder erosion through the urethra and distal penile shaft

requires explantation and repair of erosion site. Posterior ectopic placement of a reservoir or two-piece inflatable prosthesis are described alternatives for restoration of prosthesis function.

Penile Deformity

Penile deformity after penile prosthesis implantation can often be classified as sigmoid (S) shaped or as supersonic transporter (SST) shaped. S-shaped penile deformity is often the result of oversized cylinders or poor distal corporal dilation [61]. This deformity is often accompanied with pain from corporal stretching [62] and requires undersized cylinder replacement in the case of semi-rigid prosthesis or simply rear tip extensor undersized replacement, if rear tip extensors were used. SST deformity is often a consequence of undersized cylinders or capsule stretching of semi-rigid cylinders that lead to poor glans support. This often requires replacement with longer cylinders or the addition of rear tip extensors if possible. One minimalist alternative that can be used in smaller degrees of deformity is performing a dorsal glans fixation to the tunica albuginea of the corpora cavernosa [63, 64].

Auto-inflation

With the introduction of lock-out mechanism in pumps by the two major manufactures auto-inflation has become a less common complication [23, 65]. Careful reservoir placement in a retropubic position can minimize back pressure overload. Cylinder deflation during the first post-operative weeks and cylinder deflation when not

Fig. 43.4 Pump scrotal erosion



in use are also important to prevent capsule contraction around the reservoir. Capsule release can be an effective measure to solve auto-inflation and it can be safely performed through laparoscopy [66]. Other effective measures might be pump replacement with newer models that already boast a lock-out valve mechanism.

Glans Necrosis

Glans necrosis following penile prosthesis implantation, although extremely rare, is a devastating known complication. The presence of preoperative comorbidities as arteriosclerotic cardiovascular disease, diabetes mellitus, smoking, previous prosthesis explantation, and previous radiation therapy as well as adjunctive procedures as sliding technique for penile lengthening and coincident distal urethral injury repair have been advocated as risk factors for post-operative glans necrosis [67]. Moreover, immediate prosthesis removal is recommended in the presence of high-risk factors as expectant management often leads to significant glandular loss [67].

43.3 Penile Revascularization and Deep Dorsal Vein Ligation

43.3.1 Surgical Technique

Penile revascularization is a reconstructive surgical strategy for men with ED that was first described by Dr. Michal in 1973. Since that time,

other surgeons have reported variations to Michal's techniques. All share the common surgical goal of restoring arterial blood flow and perfusion pressure to the corpora cavernosa, and is based on three main concepts. The first involves the creation of an arterio-arterial shunt from the inferior epigastric artery (IEA) to the dorsal penile artery (DPA) or cavernosal artery in an end-to-end or end-to-side fashion. The second creates an arteriovenous shunt, in which the IEA is anastomosed to the DPA and deep dorsal vein. The third develops venous arterialization through anastomosing the IEA to the deep dorsal vein with additional proximal and/or distal vein ligation [20, 68–71].

Currently, this surgical approach starts with the dissection and isolation of the dorsal penile artery or deep dorsal vein through an infrapubic or scrotal incision. If a scrotal approach is chosen, an incision is made below the penoscrotal junction in the opposite side of the planned abdominal incision for the inferior epigastric artery harvesting. Finger blunt dissection along the Buck's fascia allows for inversion of the penile shaft. The fundiform ligament is identified and preserved to minimize penile shortening. The selected dorsal artery or vein is isolated and mobilized proximally while avoiding injury of the dorsal nerves [69, 71, 72]. Harvesting of the IEA can be made through either an open or laparoscopic approach. The IEA is identified and mobilized from its origin at the level of the external iliac artery to umbilicus. The distal end of the IEA is clipped near the umbilicus, divided, and

then transferred to the dorsal aspect of the penis [69, 71].

In cases of microvascular anastomosis between the IEA and the dorsal penile artery, the DPA is mobilized and divided in a proximal location on the penile shaft. The proximal end is cauterized using the bipolar cautery. Aneurysmal clips are placed on both the DPA and the IEA, and a microsurgical end-to-end or end-to-side anastomosis is performed using a simple interrupted stitching technique [69, 71]. In cases of microvascular anastomosis between the IEA and the deep dorsal vein, the latter is isolated and its valves are rendered incompetent, or alternatively can be left intact. The circumflex and emissary collaterals are identified and ligated, and end-to-end anastomosis between the IEA and the dorsal vein is carried out. The dorsal vein is ligated proximal to the anastomosis and distally at the level of the retrocoronal venous plexus [69, 71].

In addition to traditional penile microarterial bypass surgery (MABS), other techniques for penile revascularization have been described, including small vessel angioplasty with or without stenting, and endovascular revascularization of larger donor vessels such as the internal iliac artery, common iliac artery or aorta artery [73].

In the setting of veno-occlusive dysfunction, venous ligation or embolization procedures have been described. Its aim is to interrupt at least one upstream or downstream venous branch, thereby preventing retrograde drainage or glandular venous congestion, respectively [68].

43.3.2 Patient Selection

As in the case of many surgical techniques, patient selection is the key to optimizing clinical outcomes. From systematic literature research and recent statements of consensus panels, it is obvious that individualized vascular surgical techniques may be beneficial in carefully selected patients, while the majority of patients with generalized vascular disease should be treated medi-

cally or in the case of failure by implantation of penile prosthesis [20, 73].

Following a careful and complete history, physical examination, and basic laboratory studies, several examinations are useful in further defining the etiology of erectile dysfunction in terms of arterial insufficiency, the presence of venous leakage, and the anatomy of the functional deficits.

There are multiple tests that are used to diagnose arteriogenic causes of ED; however, contemporary approaches include either penile duplex doppler ultrasonography (PDDU) or dynamic infusion cavernosometry, with the former representing first-line erectile hemodynamics assessment. In cases where arterial insufficiency is found on functional testing, selective internal pudendal angiography (SIPA) or computed tomographic (CT) angiography and venography are used to assess the anatomy of the arterial and venous tree in an effort to define location and degree of stenosis [71, 74].

Currently, there is no consensus on the indication for vascular surgery. However, the members of the 2015 International Consultation on Sexual Medicine recommended that penile revascularization should be limited to men with ED who are younger than 55 years old with a history of a recently acquired ED from focal arterial occlusive or traumatic disease in the absence of other systemic risk factors for ED such as smoking, diabetes mellitus, hypertension or hypercholesterolemia as well as those with hormonal and neurological etiologies.

Venous surgery or embolization for the treatment of veno-occlusive dysfunction is not recommended. Damage at the cellular level produces a deficit in erectile physiology that is not compensated directly by venous ligation. However, these surgeries or procedures can be performed in the setting of clinical studies with appropriate informed consent, standardized methods of diagnosis and surgical treatment, including the use of standardized questionnaires and long-term follow-up.

43.4 Conclusion

To date, despite consistent outcomes suggesting potential benefits in select individuals, penile revascularization has failed to achieve mainstream acceptance. This is likely due to several reasons, including the complexity of surgery, diverse number of procedures available, narrow guideline statements, and viable alternatives with good outcomes. In the setting of more standardized approaches, penile revascularization could play a more significant role in the management of select subtypes of ED.

Key Summary Points

- The standard surgical treatment of erectile dysfunction is the implantation of a penile prosthesis.
- Penile prosthesis materials and design have improved along the last decades, contributing to a low rate of mechanical complications and long-term durability.
- Both penile prosthesis hydrophilic- and antibiotic impregnated-coatings as well as new operative approaches, such as the “no touch” approach, have greatly contributed to the lower rate of post-operative infection observed in recent years.
- Surgeons must be aware of both intra- and post-operative complications of penile prosthesis implantation and their management.
- Penile revascularization still has a role in the surgical treatment of erectile dysfunction, although patient selection is key.

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Penile Prosthesis Implantation: Penoscrotal Approach

44

Hussain M. Alnajjar and David J. Ralph

44.1 Introduction

Patients with erectile dysfunction (ED) are often initially managed with lifestyle changes, oral pharmacotherapy and Vacuum Erection Device (VED). If these measures fail, patients may be commenced on intracavernosal injections or intraurethral medications consisting of Alprostadil. Examples of intracavernosal and intraurethral medications are Caverject® and MUSE® respectively.

In the event that none of the above conservative measures or treatments work, implantation of penile prosthesis may be considered. The term “end-stage” or “refractory” ED is used in patients who have exhausted all medical treatments. However, penile prosthesis may be inserted in the absence of end-stage ED, due to other reasons, such as patient choice (dissatisfaction with or contraindication to oral or intracavernosal pharmacotherapy use), Table 44.1.

Table 44.1 Indications for penile prosthesis insertion

Indications and Patient Selection
Refractory erectile dysfunction
Failure to tolerate pharmacotherapy/patient choice
Refractory ischaemic priapism
Buried penis
Difficulty with using condom sheath for incontinence
Neurological conditions/spinal injury

This is a crucial step to ensure that patients have made fully informed decisions and that they understand what the surgery entails and its intended objectives. Patients should also be provided with adequate training and information beforehand. It is highly recommended that patients should be provided a demonstration of the various devices allowing them to understand how the devices operate, familiarize themselves with the pump and how to cycle the device. This will also allow them to appreciate the feel and texture of the various components of the device. It is crucial to provide patients with written information concerning the surgery, options of prostheses, advantages versus disadvantages, and potential risks associated with the operation (Table 44.2). Patients should be given sufficient time to come to a decision prior to proceeding with surgery. It is also important to involve their partner, if possible.

During patient counselling, particular considerations should be given to patient’s medical and surgical history when considering the type of penile prosthesis. A summary of specific

44.2 Patient Selection and Counselling

Patients undergoing penile prosthesis surgery require a detailed pre-operative assessment and counselling prior to their operation (Fig. 44.1).

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Penile Prosthesis Counselling

Name:.....

Referring consultant:.....

Hospital No.:.....

Consultant:.....

Cause of ED & management to date:

IIEF & EDITS:

PMH incl. LUTs, abdominal scars/ Hernia &

BMI & waist circumference

Medication incl. anticoagulants:

Manual dexterity:

Implant types demonstrated:

Malleable implants and inflatable incl. Genesis & Titan Touch

Risks discussed:

Infection, erosion, bleeding, auto-inflation, glans droop, urethral injury, altered glans sensitivity. Average lifespan of inflatable devices=10yrs

What an implant will do:

Essentially it is internal scaffolding providing rigidity and maintenance of erection

What it won't do:

Implants WILL NOT provide extra length to penis and WILL NOT restore length lost through prolonged erectile dysfunction/ Peyronie's disease. Unlike the vacuum device and intraurethral/ intracavernosal alprostadil, a penile prosthesis WILL NOT provide engorgement to the penile tissues.

Non reversible:

Corporal tissue is damaged/ destroyed when spaces are created for placement of the cylinders/ malleable rods and therefore surgery is considered an end stage procedure

Pre-operative requirements and post-operative care:

Must attend PAC, Must have negative MSU, LOS, time off work, pain, follow up

Added to waiting list: YES/ NO

Agreed to data collection – audit and prosthesis audit YES/NO

Deferred for medical reasons/ patient wishes to consider options/ further OPA/ Speak to another patient.

All points have been discussed today

Signature's CNP:.....Patient.....Date.....

NB: Patient advised that all penile prosthesis cases are discussed at a dedicated meeting to confirm suitability for prosthesis surgery

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Fig. 44.1 Penile prosthesis counselling proforma (Courtesy of Clare Akers and Fiona Holden)

Table 44.2 Consent proforma, potential risks associated with penile prosthesis insertion

Infection
Bleeding
Soft glans/Super-Sonic Tilt (SST)
It will not increase penile length
Mechanical failure
Urethra, bladder, bowel injury
Glans hypoaesthesia
Erosion

Table 44.3 Patient factors to be considered before choosing the most suitable penile prosthesis

Diabetes mellitus
Spinal cord injury
Manual dexterity
Previous pelvic surgery
Previous radiotherapy
Presence of Artificial Urinary Sphincter (AUS)
Immunosuppression
Penile conditions e.g. Peyronie's disease, acute or chronic priapism, phimosis
Stretched penile length
Body habitus
Abdominal scars/presence of stoma
Scrotal size
Patient's preference

Table 44.4 Absolute indications for penoscrotal approach

Absolute indications for penoscrotal approach
Peyronie's disease
Corporal fibrosis
Obesity
Presence of artificial urinary sphincter
Phalloplasty

considerations to patient factors when choosing the most suitable penile prosthesis is listed in Tables 44.3 and 44.4.

44.3 Penile Prosthesis Types and Options

The current and most commonly used inflatable penile prostheses are from two companies, Coloplast Corporation (Denmark) and Boston Scientific (USA).

Coloplast currently markets Titan® Touch, a self-contained three-piece fluid filled system with an incorporated hydrophilic coating on all components. It is made from the durable Bioflex® and silicone materials. The coating allows for soaking of the device in an antibiotic solution according to the surgeons' preferred choice of antibiotics prior to implantation to reduce infection risk and aid in surgical placement. The Titan IPP products are available in a variety of lengths ranging from 11 cm to 28 cm.

Coloplast has also designed a hydrophilic coated Cloverleaf™ reservoir with a lock-out™ valve mechanism to reduce risk of auto-inflation. The reservoir comes in two volumes, 75 ml and 125 ml for the larger cylinders. The one touch pump with the deflate button allows for easy deflation of the device. The narrow base version of the Titan® Touch allows implantation of prosthesis in patients with fibrosed and or narrow corpora.

Comparably, Boston Scientific manufactures AMS 700™ three-piece inflatable prosthesis. There are 3 variations available in the AMS 700™ inflatable penile prosthesis line.

AMS 700™CX is the standard IPP with controlled expansion of cylinders aiming to optimize girth and offer additional length options.

AMS 700™LGX is the only marketed penile implant with cylinders designed to expand in girth and length of up to 25%.

AMS 700™CXR is the equivalent to the Coloplast narrow base IPP, for narrower or fibrosed corpora.

The AMS 700™ inflatable penile prosthesis line is available in a variety of lengths ranging from 12 cm to 24 cm.

The AMS 700™ spherical reservoir comes in two volumes, 65 ml and 100 ml. Whereas AMS™ Conceal™ flat reservoir comes in 100 ml only. The Conceal™ low-profile reservoir is Parylene coated to enhance durability and optimises fit and flexibility. The AMS Momentary Squeeze (MS) pump™ offers one-touch button designed for easy deflation, it also has a lock-out valve incorporated within the pump mechanism to resist auto inflation.

AMS 700™ is the only antibiotic impregnated inflatable penile prosthesis on the market, it is pre-coated with Inhibizone™ antibiotic surface treat-

ment. Inhibizone™ is a combination of Rifampicin and Minocycline, it aims to create a zone of inhibition against bacteria that are commonly associated with penile prosthesis infection.

Boston Scientific also markets the only two-piece inflatable penile prosthesis currently available, the AMS Ambicor™. This pre-filled, pre-connected device eliminates the need for a separate reservoir, resulting in a two-piece designed for ease of placement. This device is particularly useful in patients with a history of complex abdomino-pelvic surgery, where retro-pubic or intraabdominal reservoir placement can be very difficult and to be avoided.

Malleable penile prostheses are an alternative option particularly useful for patients with restricted manual dexterity (e.g. rheumatoid arthritis) or whom require penile projection for other reasons (e.g. placement of urinary containment sheath or for other voiding issues). Both Coloplast and Boston Scientific manufacture malleable penile prostheses which can be an alternative option for patients who do not wish to have a three-piece inflatable penile prosthesis. The Coloplast Genesis™ has a hydrophilic coating in the same way as the Coloplast three-piece devices. AMS Spectra™ does not have Inhibizone™ or any other coating (Table 44.5 and Fig. 44.2).

44.4 Patient Preparation

Following patient counselling and medical clearance by the pre-assessment team, it is imperative for patients to be cleared of any uri-

nary tract infection. Confirmation of a negative urine culture is mandatory. Patients should also undergo *Methicillin Resistant Staphylococcus Aureus* (MRSA) screening and be cleared of any cutaneous infection (e.g. intertrigo or fungal rashes). Diabetic patients must have their blood glucose levels under strict control with HBA1c below 8%. One of the major concerns associated with prosthetic surgery is the potential risk of infection. Skin flora is most common cause of early prosthetic infection due to bacterial entry and contamination during the time of surgery [1]. Studies have shown chlorhexidine-alcohol based scrub was superior to povidone-iodine in eradicating skin flora at the surgical skin site before genitourinary prosthetic implantation. Two studies reported chlorhexidine-alcohol to be the optimal agent for skin preparation before genitourinary prosthetic procedures with lower post-preparation positive skin cultures [2, 3]. A 10-minute 4% w/v chlorhexidine-gluconate cutaneous scrub or povidone-iodine scrub followed by 2% chlorhexidine gluconate and 70% isopropyl alcohol prep (e.g. Chloraprep®) is recommended to minimize infection. Eid et al. reported infection-retardant coatings of penile implants lower the risk of infection from 5.3% to 2%. The “no-touch” enhancement which involves the use of additional and adhesive skin barrier draping decreases the rate of infection to 0.46% [4].

The theatre environment must be suitable for prosthesis surgery. Laminar flow should be employed. Prosthesis surgery sign post should be clearly displayed outside the theatre doors and

Table 44.5 Coloplast and Boston Scientific penile prosthesis types

Device manufacturer/name	Type	Coating	Length (cm)	Diameter (mm)
Coloplast				
Titan One-Touch Release (OTR)	3-piece inflatable	Hydrophilic	14–22 (XL 24–28)	21+
Titan One-Touch Release (OTR) Narrow-base	3-piece inflatable	Hydrophilic	11–18	17
Genesis	Malleable	Hydrophilic	14–27	9.5, 11 & 13
Boston Scientific				
AMS 700 CX	3-piece inflatable	Inhibizone	12–24	12–18
AMS 700 CXR	3-piece inflatable	Inhibizone	10–18	9.5–14.5
AMS 700 LGX	3-piece inflatable	Inhibizone	12–21	12–18
AMS Ambicor	2-piece inflatable	None	14–22	12.5–15.5
AMS Spectra	Malleable	None	12–26	9.5, 12 & 14



Fig. 44.2 (a) Coloplast One-Touch Release penile prosthesis, (b) AMS 700 CX penile prosthesis, (c) Coloplast Genesis malleable penile prosthesis, (d) AMS Spectra

malleable penile prosthesis, (e) 2-piece AMS Ambicor inflatable penile prosthesis. (With permission from Coloplast Corporation and Boston Scientific)

staff traffic minimised. All theatre personnel should be wearing disposable face masks at all times. Extra care and caution should be taken by every team member to ensure risk of contamination is kept to insignificant.

Generally, a minor surgical set should be sufficient for penile prosthesis surgery (Fig. 44.3). However, a number of special equipments are required in order to complete the procedure successfully. We will



Fig. 44.3 A minor surgical set with a number of specific surgical instruments

discuss such instruments in the next section of this chapter.

44.5 Surgical Procedure (Peno-Scrotal Approach)

Following a full shave of the external genitalia and the suprapubic region, a 10-minute 4% w/v chlorhexidine-gluconate cutaneous scrub or povidone-iodine scrub followed by 2% chlorhexidine gluconate and 70% isopropyl alcohol prep (e.g. Chloraprep®) is recommended (Fig. 44.4).

A traction suture through the dorsum of glans penis can be used to keep the penis on stretch, alternatively the sharp hook for the Scott retractor can be sited into the urethral meatus.

A temporary drape with a hole at its centre is placed over the penis. A 14-Fr Foley catheter is inserted using an antibiotic soaked swab to hold the penis, hence avoiding contact with the meatus or the potentially contaminated excess lubricant overflowing out of the meatus. The visible part of the catheter is wiped by the antibiotic soaked swab and spigotted. The swab, drape and surgical gloves should be discarded and exchanged at this stage.

The aim of the catheter is to help identify the urethra safely and easily, to drain the bladder prior to insertion of the reservoir in the retropubic (retzius) space.

44.5.1 Incision and Corporotomies

A transverse incision is made 1 cm below the penoscrotal junction (Fig. 44.5). However, a ventral phalloplasty reconstruction can be performed if a penoscrotal web is present and the excess tissue is excised. A scott ring retractor with hooks can be used at this point which helps maintain a good exposure. Careful dissection of the dartos layer allows identification of urethra and corpora. The catheter aids to identify the urethra easily and reduces risk of inadvertent urethral injury. Once the urethra has been identified, lateral dissection either by monopolar diathermy or Metzenbaum scissors exposes both corpora. Stay sutures with 0 Vicryl (5/8 circle needle) are placed parallel to each other and on either side of the planned corporotomy site (Fig. 44.6). The corporotomy must be made as low as possible to hide the exit tubing and give a better cosmetic result (Fig. 44.7). This is exactly repeated on the



Fig. 44.4 10-minute scrub with Povidone-Iodine from umbilicus to mid-thigh level



Fig. 44.5 Incision site 1 cm below penoscrotal junction

contralateral side. The corporotomy is performed in between the traction sutures with cut diathermy or a scalpel and limited to spongy tissue. Metzenbaum scissors are used to develop a plane

for further dilatation of the corpora proximally and distally. If the corpora is fibrotic at the site of the corporotomy, it should be excised by cut diathermy (mini excavation) in order to allow exposure of healthy spongy tissue as well as help with closure of the corpora later on once the implant is inserted.

44.5.2 Corporal Dilatation and Measurements

Corporal dilatation should be performed carefully using either Brooks or Hegar dilators. Brooks dilators (Fig. 44.8) have the benefit of being tapered, however, provide less resistance during dilatation and therefore are more prone to causing perforation of the corpora if not used cautiously compared to Hegar dilators. Hegar dilators in sizes ranging 8–14 mm are sufficient for majority of cases. Proximal dilatation involves dilating the corpora carefully in a slight lateral angle as the corpora diverge laterally until touching the base of the corpora on the ischiopubic ramus, where the dilator should be advanced without an undue

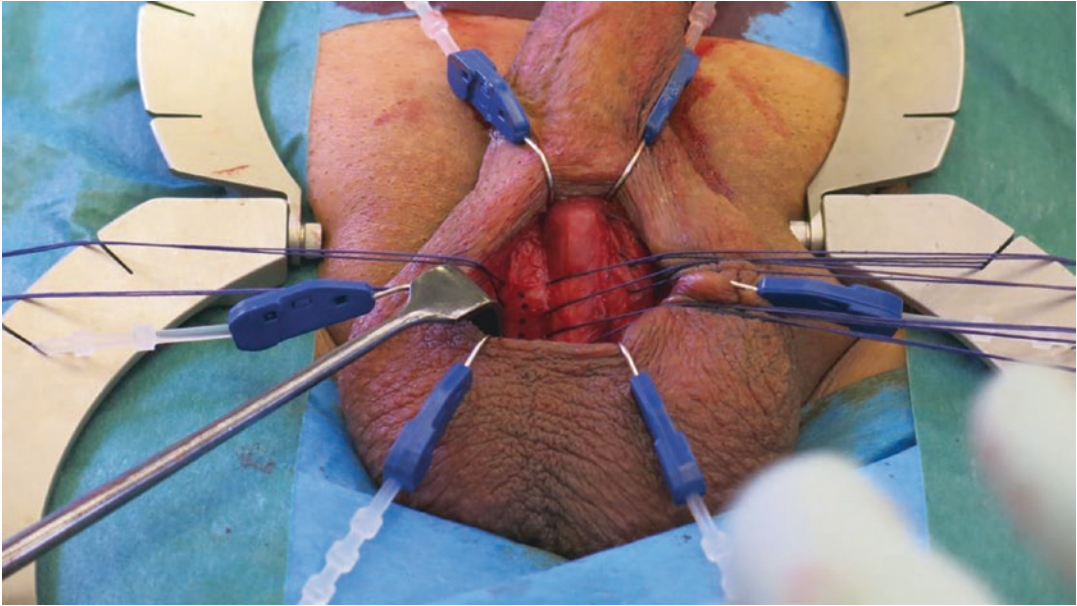


Fig. 44.6 Corporal stay sutures with dotted line delineating corporotomy site



Fig. 44.7 Prominent tubing on the shaft and penoscrotal junction due to high corporotomy

force (Fig. 44.9). Whereas with distal dilatation, it requires the surgeon to grasp the urethra between the left-hand's thumb and index fingers and pushing it to the contralateral side (Fig. 44.10). The dilatation starts with size 9 mm Brooks and up to 12 mm Brooks. The Brooks dilators should be aimed as laterally as possible in order to avoid inadvertent urethral injury or a cross over across the midline septum into the contralateral corpora, while holding the urethra away from the corpora which is being dilated. In difficult situations,



Fig. 44.8 Brooks dilators

where there is marked cavernosal fibrosis, Rossello dilators can be used. The rough ridges which grate the tissue when withdrawn should be facing laterally whereas the smooth surface of the dilator should be facing the urethra only (Fig. 44.11). Like the Brooks and Hegar dilators, they are available in serial sizes for sequential dilatation. Access to all three types of dilators is

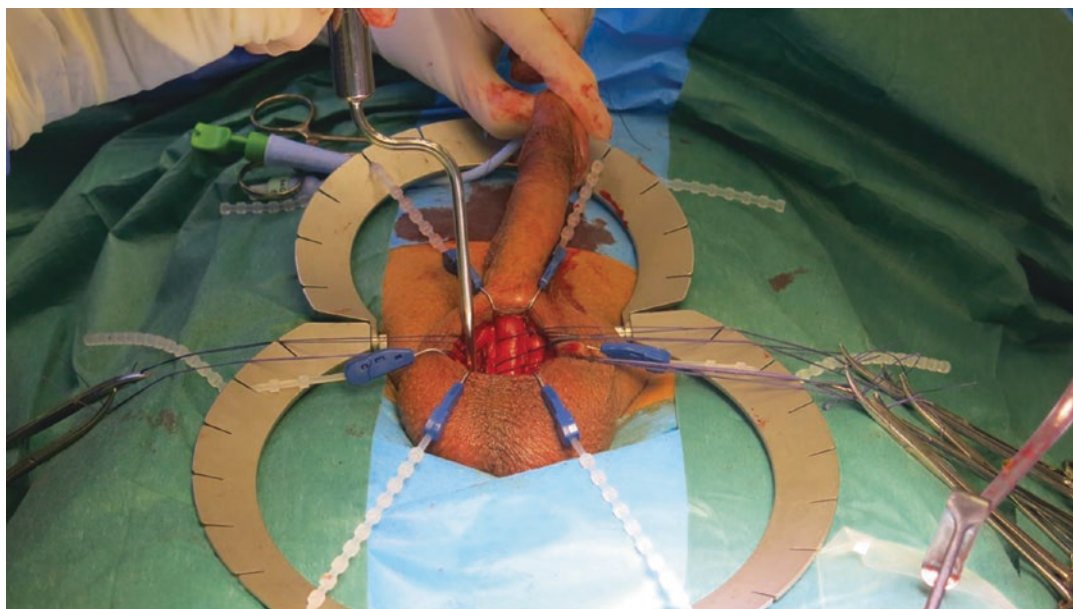


Fig. 44.9 Proximal corporal dilatation with Brooks dilators



Fig. 44.10 Distal corporal dilatation, aiming laterally with Brooks dilators

crucial to cover any eventuality during penile prosthesis surgery.

Following completion of distal and proximal dilatation, dilators are inserted concomitantly on both sides to test for metal clinking sound in case of a cross-over. This safety check manoeuvre

should be performed both proximally and distally. A goalpost sign should be confirmed where both dilators are symmetrical without any discrepancy in the levels of the dilators (Fig. 44.12). The goalpost sign rules out a corporal perforation or under dilatation. Antibiotic solution

(Rifampicin and Gentamicin) is used to irrigate the corpora at this stage. This minimises risk of implant infection and helps to rule out inadvertent urethral perforation during distal dilatation. If the antibiotic solution leaks out of the meatus, it is an indication of a urethral perforation.

Both corpora are measured precisely, proximally and distally by a Furlow instrument (Fig. 44.13). This can be carried out by using an artery clip to mark the length measurements at

the corporotomy lip. Accurate recorded measurements are essential for correct implant sizing. It is important not to oversize or undersize by either forceful stretching of the penis with the furlow or by doing the opposite. Generally, it is advisable to use maximum size of the cylinder with a minimum length of rear tip extenders (RTE), as it leads to superior axial rigidity and easier future revision of the implant.

44.5.3 Preparation of the Implant and Insertion of Cylinders

The penile prosthesis is prepared by expelling air from the system and by using shod clamps to prevent air entry. Coloplast IPP should be soaked in an antibiotic solution before handling the device (Fig. 44.14), this is not required for AMS devices. At this stage, the cylinders are inserted into the corpora using the Furlow inserter and a Keith needle provided in the kit to guide the distal tips of the implant into the corpora distally. The needle is passed through the glans and the proximal part of the cylinder is placed in the corpora, sub-



Fig. 44.11 Rossello dilators

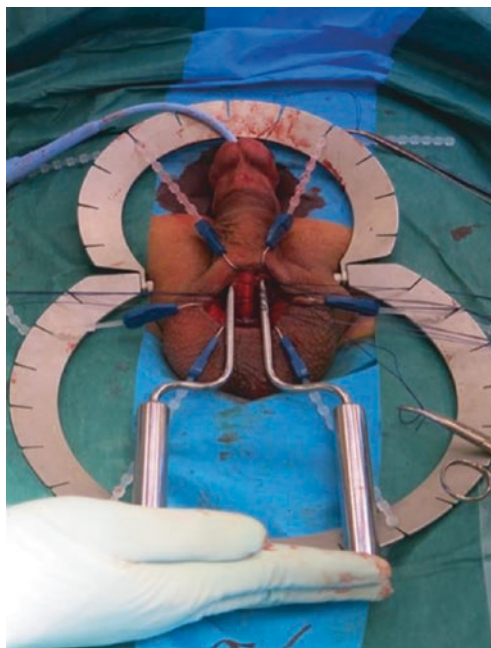


Fig. 44.12 Distal and proximal goalpost sign

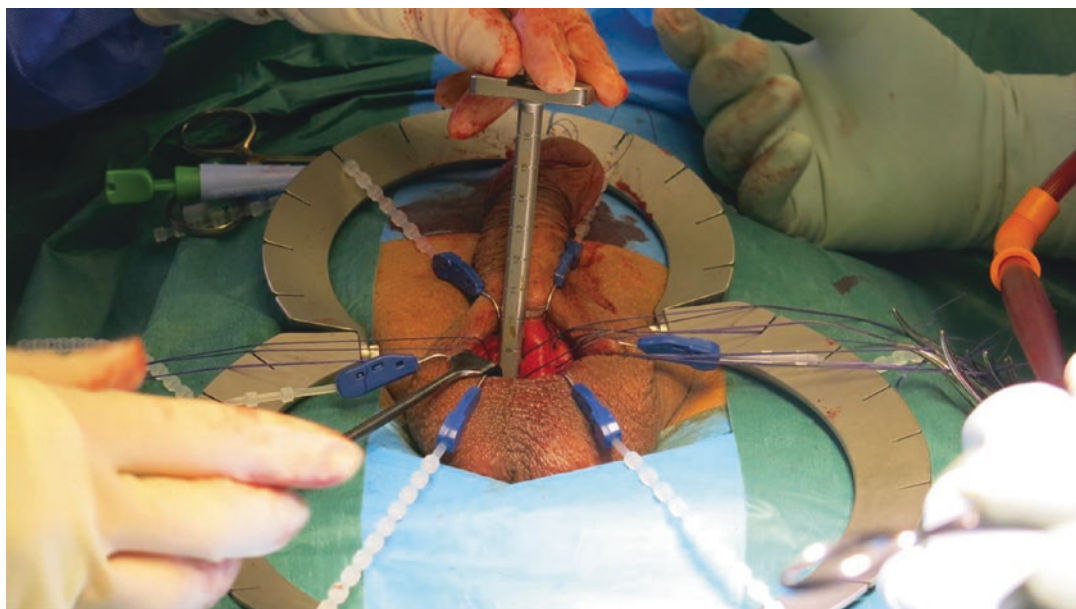


Fig. 44.13 Proximal corporal measurement with Furlow inserter, using an artery clip to mark the length measurements at the corporotomy lip (not shown in this illustration)

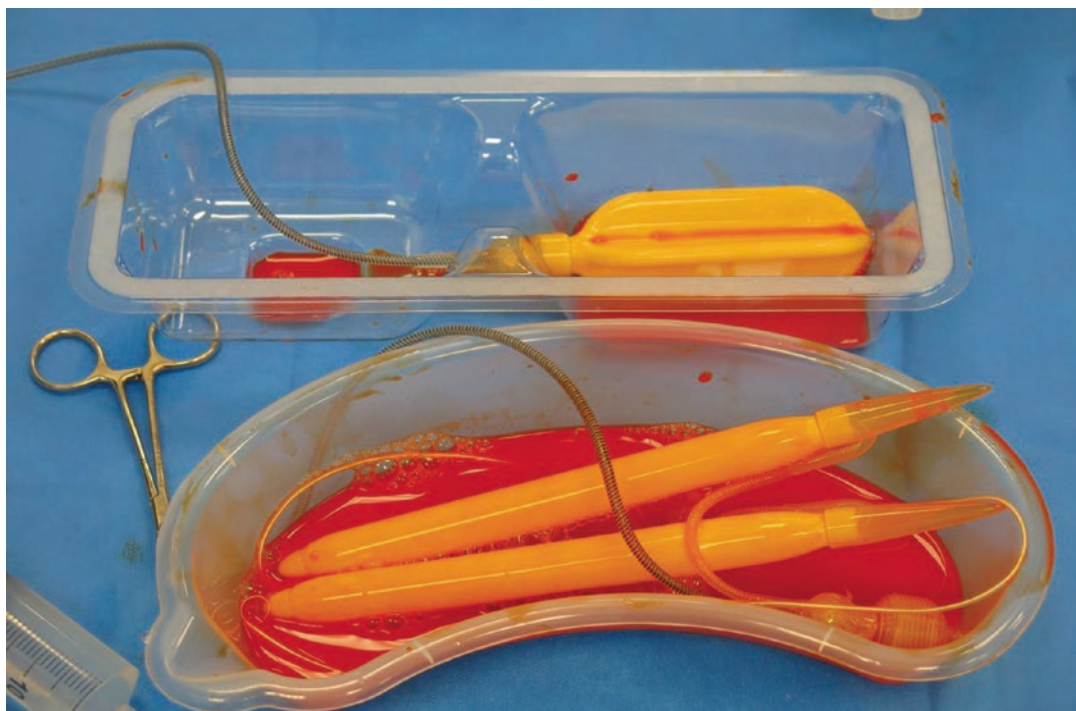


Fig. 44.14 Coloplast IPP soaked in antibiotic solution (Rifampicin & Gentamicin) before handling the device

sequently the suture is pulled to place the distal part into position. The Furlow is used to push and place the proximal ends of the cylinders into the correct site. The stay sutures are tied securely to seal and close the corporotomies.

44.5.4 Blind Insertion of the Reservoir

Routine reservoir placement is by blind insertion and placement in the retropubic space (retzius) through the superficial inguinal ring, however, this technique is contraindicated if the patient has had previous pelvic surgery. The bladder should be emptied before placing the reservoir. The superficial inguinal ring is identified and the fascia transversalis is pierced to enter the retropubic space. A long nasal speculum is placed through the defect in fascia transversalis and into the retzius space (Fig. 44.15). The reservoir is then placed by opening the nasal speculum, a ring clamp can be used to grasp the lowermost part of the Coloplast reservoir and inserted into the space. A Furlow can be used to gently push the reservoir deeper inside the space. The use of ring clamp is avoided with the AMS device as it can damage the device. The reservoir is then filled with the appropriate amount of fluid (0.9% saline). It is important to ensure that the reservoir is not herniating through the site of puncture.



Fig. 44.15 Blind reservoir insertion into the space of retzius through the superficial inguinal ring, using a long nasal speculum

44.5.5 Open Insertion of the Reservoir

The open technique for the insertion of the reservoir is utilised in cases where the patient has undergone previous abdomino-pelvic surgery. To minimise risk of injury to the bowel or urinary diversion, the reservoir is placed in the lateral retroperitoneal space through an iliac fossa incision. The incision is placed 2 cm medial and inferior to the anterior superior iliac spine. It is extended 3 cm inferiorly and parallel to the inguinal ligament. Once the skin incision is made, dissection is performed through the subcutaneous adipose tissue and Camper fascia. The external oblique fascia is identified and incised 2 cm along the direction of its fibres (Fig. 44.16), a blunt muscle splitting manoeuvre is used to spread the internal oblique and transversus abdominis muscles, this can be achieved either by spreading 2 Langenbeck retractors apart or by spreading a curved Mayo scissors (Fig. 44.17). At this stage, transversalis



Fig. 44.16 Iliac fossa incision, showing external oblique muscle. Blue mark is the line of incision along the fibres of the external oblique



Fig. 44.17 Blunt muscle fibre splitting of the internal oblique and transversus abdominis, leading to transversalis fascia

fascia is bluntly dissected and the retroperitoneum is entered. A finger-sweeping manoeuvre is used to create a space for the reservoir. Once the reservoir is placed in the created space (Fig. 44.18), the fascia is closed continuously with 2–0 vicryl sutures. The reservoir is filled with 0.9% saline ensuring there is no backpressure or herniation through the fascia. The reservoir tubing is tunneled under the external oblique fascia in to the scrotal wound using a Roberts curved artery forceps. The tubing is trimmed and connected using the accessory/assembly kit.

44.5.6 Placement of the Pump

A subdartos space should be made in the most dependent part of the scrotum between the two testicles, to enable the patient to palpate and cycle the device effortlessly. This is performed prior to the definitive cylinder placement to ensure that tubing lengths are correct. Excessive



Fig. 44.18 Insertion of the reservoir into the lateral retroperitoneal space

lengths of tubing in the scrotum should be trimmed to conceal the device.

The provided kit is used to connect the tubing, ensuring that no air enters the system. At this point, the device is inflated to ensure appropriate positioning and to recognize any penile deformities, which would have to be dealt with intraoperatively.

44.5.7 Ectopic Insertion of the Reservoir

This is an alternative technique to open insertion of the reservoir, which is safer than the blind insertion technique. A high submuscular placement of the reservoir through the posterior wall of the inguinal canal. The Coloplast (125 ml) Cloverleaf™ or the conceal reservoir by AMS (100 ml) is placed behind the rectus muscle and anterior to transversalis fascia. The reservoir is intentionally under-filled to minimum cylinder requirement to conceal it.

44.5.8 Closure of the Incision

At this stage, meticulous haemostasis is crucial and a 10 French closed-suction drain may be placed. A multi-institutional study has shown that closed-suction drain reduces the risk of post-operative haematoma and swelling, without increasing the infection rate and yielding earlier recovery time [5].

It is common practice to partially inflate the device and leave it inflated for approximately 12–24 hours to reduce any risk of corporal bleeding. The pump is secured in its subdartos space with absorbable suture to prevent it from migrating into inaccessible locations which may be difficult for the patient to cycle the device. The scrotum is closed in several layers with absorbable sutures, ensuring that pockets of dead space are obliterated to reduce the risk of post-operative haematoma or swelling.

44.5.9 Wound and Penoscrotal Dressing

Finally, a ‘mummy wrap’TM compressive dressing is applied to the scrotum and penile shaft to minimise the risk of haematoma formation or oedema [6]. Typically, the dressing is removed the next day. For patients on anticoagulant therapy, or for other reasons, the wrap may be left on for 48 hours. The Foley catheter can be left in situ as long as the wrap is on, as some patients can have difficulty voiding with the mummy wrap (Fig. 44.19).



Fig. 44.19 Mummy wrap

Both device manufacturers include a form with the packaging of the device. This form should always be filled and returned to the company in order for this information to be archived as a future resource in case of revision surgery. A copy of the form should also be placed in the patient's medical records. The data can also be useful for future retrospective review.

44.6 Post-Operative Care

Usually patients are admitted for approximately 24 hours for observation and pain management. The following day the mummy wrapTM and urethral catheter are removed and the inflatable penile prosthesis is deflated. In patients who have an artificial urinary sphincter in-situ, it should be reactivated at this stage. Once the patient is voiding freely and the drain output has remained low after removal of the dressing and deflation of the implant, the closed-suction drain is deactivated and removed before discharging the patient. Patients are routinely given 2 doses of intravenous post-operative antibiotics of choice according to the local hospital protocol. Patients are also discharged on oral antibiotics for 7 days. There is lack of uniformity among urologists performing prosthetic surgery with regard to antibiotic protocols. A study of prosthetic surgeons has shown that the majority (90%) prescribed an average of 7 days of post-operative antibiotics [7].

Patients usually return to clinic for follow-up at 3 weeks for assessment, education and device cycling. Patients are also instructed not to resume any sexual activity until 6 weeks post-procedure.

44.7 Conclusion

The penoscrotal approach for penile prosthesis implantation is the most common surgical technique used for the management of end-stage ED. The approach offers superior corporeal, proximal crural exposure, avoids the risk of neurovascular bundle injury and pump migration. Furthermore, artificial urinary sphincters (AUS) can be inserted

through the same incision and approach. The penoscrotal scar provides a better cosmetic result. Finally, revision surgery of an IPP through the penoscrotal approach is less challenging.

Key Summary Points

- Appropriate patient selection and detailed pre-operative patient counseling are crucial
- Patients should be given sufficient time to come to a decision prior to proceeding with IPP surgery. It is also important to involve their partner, if possible
- Penile prosthesis may be inserted in the absence of end-stage ED, due to other reasons, such as patient choice (dissatisfaction with or contraindication to oral or intracavernosal pharmacotherapy)
- Confirmation of a negative urine culture, *Methicillin Resistant Staphylococcus Aureus* (MRSA) screening and clearance of any cutaneous infection (e.g. intertrigo or fungal rashes) is mandatory
- Diabetic patients must have their blood glucose levels under strict control with HBA1c below 8%
- Brooks dilators have the benefit of being tapered, however, provide less resistance during dilatation and therefore are more prone to causing perforation of the corpora if not used cautiously compared to Hegar dilators
- Both corpora are measured precisely, proximally and distally by a Furlow instrument. This can be carried out by using an artery clip to mark the length measurements at the corporotomy lip
- Routine reservoir placement is by blind insertion and placement in the retropubic space (retzius) through the superficial inguinal ring, however, this

technique is contraindicated if the patient has had previous pelvic surgery

- Where blind reservoir insertion is contraindicated and to minimise risk of injury to the bowel or urinary diversion, the reservoir is placed in the lateral retroperitoneal space through an iliac fossa incision
- A 'mummy wrap'TM compressive dressing is applied to the scrotum and penile shaft to minimise the risk of haematoma formation or oedema in the post-operative period

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Penile Prosthesis Implantation: Infrapubic Approach

45

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45.1 Introduction

Since the first description of the use of an internalized inflatable penile prosthesis by Scott et al. in 1973 [1], the devices and associated surgical approaches have evolved to make the operation easier, safer and more effective. Several surgical approaches for penile prosthetics have been described, including a dorsal subcoronal, dorsal penile shaft, ventral penile shaft, penoscrotal, perineal, infrapubic and suprapubic [2]. However, the infrapubic and the penoscrotal surgical incisions have stood the test of time and are commonly used for implantation of inflatable penile prosthetics. The scrotal approach is currently the most commonly performed approach, with approximately 80% of IPPs placed in this fashion

[3, 4]. The 2015 International Consultation of Sexual Medicine (ICSM) states “penoscrotal, infra-pubic, and subcoronal are the three main approaches for inserting a penile prosthesis” [5]. The surgical technique and penile prosthesis type chosen depends upon surgeon preference and may be directed by familiarity, the patient’s specific anatomy or prior surgical history.

Barrett and Furlow were the first to detail the infrapubic surgical approach in 1985 [6]. Since then, several revisions of this technique have subsequently been described in the literature, including using a penoscrotal counter-incision for pump placement [7] and a smaller infrapubic incision to make for a more minimally invasive surgical procedure [8]. Advantages to the infrapubic approach are the ability to implant the reservoir more rapidly and under direct vision through the same incision and the prevention of an extra incision, removing one obstacle to rehabilitation [5, 9]. The disadvantages that have been cited include potential damage to the dorsal nerves of the penis with resultant sensory loss (although this has never been documented in the literature), limited distal corporal exposure (similar to the penoscrotal approach), and the lack of access to the most dependent part of the scrotum for pump fixation [9, 10]. These disadvantages are overcome with careful dissection, the use of hydrodissection, the use of the nasal speculum for pump

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placement and active involvement of the patient in his own rehabilitation.

In one of the earliest studies to analyze patient satisfaction and post-operative complications for three-piece inflatable prostheses, Candela et al. showed no statistically significant difference between the penoscrotal and the infrapubic approach, including incisional discomfort, scrotal pain/edema, scrotal hematoma, incidence of penile paresthesia, or post-operative infection rate [11]. Further updates to the literature show that this continues to hold true today [4]. We will briefly describe our “Minimally Invasive Infrapubic Inflatable Penile Implant”, as first published in 2008 [8] with many additional pearls learned along the way.

45.2 Patient Selection

Any patient is a candidate for an infrapubic approach to a penile implant, including those undergoing revisions. In fact, revisions are often best served through the infrapubic approach in order to at least attempt reservoir retrieval without the need for a secondary incision, something we have not performed in over 10 years. We do recommend adopting the “drain and retain” [12] algorithm when one finds themselves uncomfortable chasing a non-infected reservoir. Our reservoir placement technique facilitates rapid and safe removal because the reservoir will be either inside or directly behind the abdominal wall. Reservoir placement through an infrapubic incision, as described below, precludes the need for a Foley catheter, which is appealing to many patients. Some 25–50% of your patients, depending upon your referral network, may have had a previous Foley catheter and found them to be extremely uncomfortable. Many patients also would prefer a 1–2 cm incision that does not involve the actual penis or scrotum. However, this approach can be challenging in obese patients, as it can be difficult to find an adequately flat surface to negotiate movement of the Furlow passer, the longest instrument utilized in the infrapubic approach. Nevertheless, careful positioning, as

described below, should alleviate this difficulty for even the most inexperienced of implanters during the infrapubic case.

45.3 Operative Technique

The patient must be positioned on the table in the dorsal recumbent position with the table hyper-extended, creating a flat surface at the mons pubis. In order to fully create this flat surface you may have to place the patient in the Trendelenburg position and even use Duct Tape to retract the draping mons out of the field. The groin hair is removed by shaving with a razor, as opposed to a clipper, as has been shown to be safe in the penile prosthetics arena [13]. The patient has been told to void prior to entering the operating room. For those that do not void, a straight catheter is used prior to decompress the bladder. When available, ensure complete emptying of the bladder with US guided PVR. The groin is then prepped with a Hibiclens® hand preparation followed by two Chloraprep™ sticks from the umbilicus to the mid thigh.

Prior to incision, patients are administered a pudendal nerve block with 10 cc of ropivacaine by scything lateral to the corpora and injecting at Alcock’s canal (Fig. 45.1). We begin the procedure with an artificial erection using a total of 60 cc of normal saline or a combination of normal saline plus lidocaine if performing the implant under pure local anesthesia. The first



Fig. 45.1 Pudendal nerve block

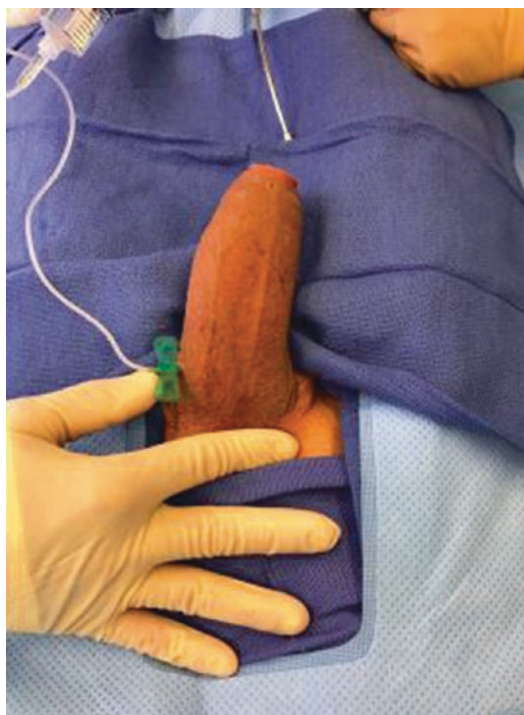


Fig. 45.2 Artificial erection/hydrodilatation of the corpora

30 cc are injected while placing pressure directly to the base of the penis in order to identify potential pathology that may have not been evident on physical exam of the flaccid penis. The remaining 30 cc is then injected to accomplish the complete hydrodilatation of the corpora supplanting serial dilation in the penis with no pathology. This hydrodilatation also allows for identification of the dorsal nerve and easy lateral placement of the stay sutures (Fig. 45.2).

The infrapubic incision is made one finger-breadth above the penile pubic junction while gently pulling down on the penis. This incision is extended only as wide as the pump (Fig. 45.3). We create a small defect in Scarpa's fascia and sweep down along either side of the penis to the level of the corpora bilaterally, sparing as many superficial vessels as possible to avoid post-operative penile edema.

A bent appendiceal retractor is used to expose the corpora, gently pushing down as opposed to pulling, allowing for greater exposure cephalad

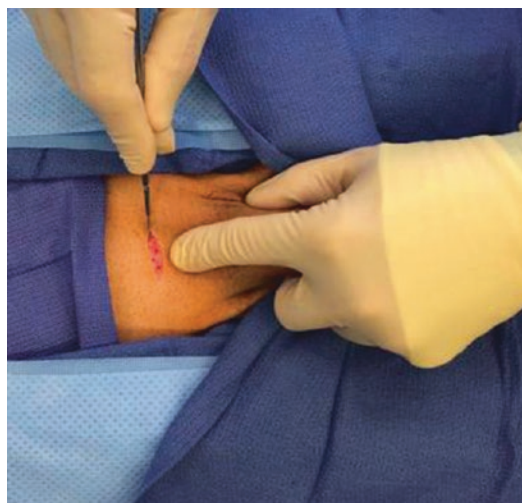


Fig. 45.3 Infrapubic skin incision

and laterally. We then use a 2-0 Monocryl™ suture on a UR6 needle to reach down and catch tunica with a sturdy needle, especially in patients that may require deeper dissections down to the corpora. A total of four stay sutures are placed (a single set of stays bilaterally). A pediatric Yankauer is utilized to roll the corpora, and thus the neurovascular bundle, out of the way before placing a single set of stay sutures bilaterally – a standard Yankauer is too large for this maneuver. This is all made very simple after the hydrodilatation of the penis, providing more corporal topography with which to work. It is important to not take too large of a bite with the stay suture, otherwise when closing, the tunica will bunch up unnecessarily, similar to a Nesbit plication. Stay sutures are eventually used as closing sutures (Fig. 45.4).

Next, we make the bilateral corporotomies with a #12 blade. The corporotomies are limited to the widest part of the cylinder at the tubing exit site, or 1.5 cm (Fig. 45.5), remembering that most, if not all post-operative bleeding occurs from these sites in virgin cases. Measurements with the Furlow introducer must be performed along the long axis of the penis with counter traction to avoid proximal perforation (Fig. 45.6). Note that dilation is not necessary unless the patient has an intracorporal pathology discovered during the artificial erection (e.g. notching, hour glass or curvature disorders). Similar measure-



Fig. 45.4 Exposed corpora with stay sutures

ment along the long axis of the penis is performed distally, pulling down on the penis while scything laterally with the Furlow introducer. One must firmly squeeze the glans in an anterior-posterior fashion to protect the fossa from perforation where the tunica comes down to only one layer. We use a 4 × 4 gauze to gain control of the glans while performing this maneuver, which allows manipulation of the Furlow introducer through any fibrotic tissue with near impunity (Fig. 45.7). Gently bouncing the Furlow keeps one from gaining too much velocity and potentially damaging the tunica. Serial dilation is not performed if there is no pathology in the penis. A Hegar #12 dilator may be used to calibrate, but not to dilate. We prefer the Hegar dilator to the Brooks dilators because the reticulating arm on the Brooks dilator can be difficult to maintain adequate control. If the #12 Hegar dilator is tight, we immediately consider using a “narrow” implant based on recent data revealing ease of implantation and absence of post-operative priapismic pain seen in patients with oversized implants [14].

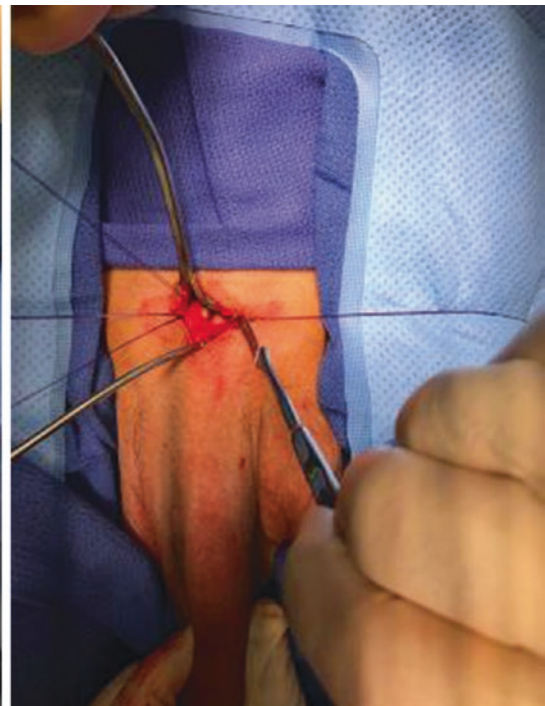


Fig. 45.5 Bilateral corporotomies are made

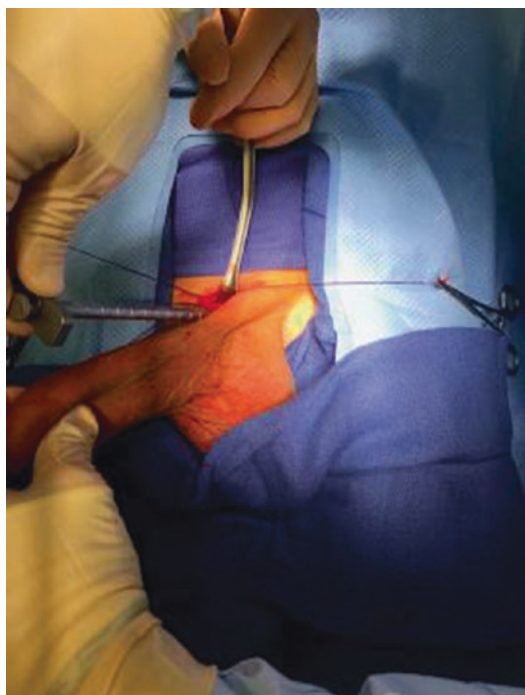


Fig. 45.6 Measuring proximally with counter-traction

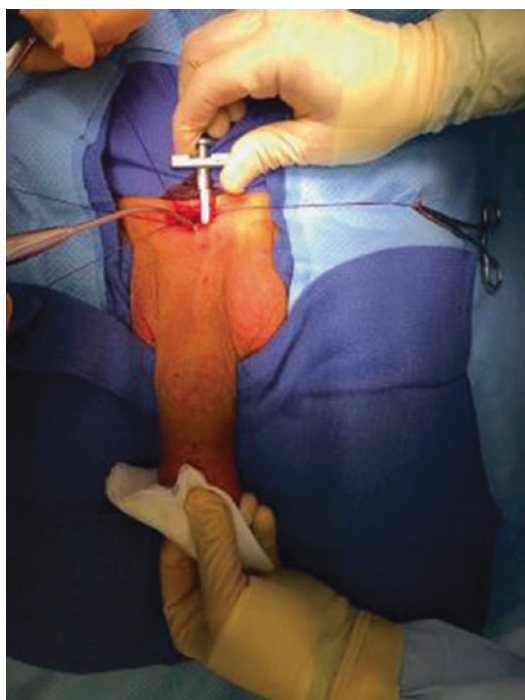


Fig. 45.7 Measuring distally along the long axis of the penis while protecting the glans

A 125 cc reservoir is always used because we prefer to underfill the reservoir in order to avoid excessive intrinsic pressures which may contribute to autoinflation. Reservoir placement in the non-compromised pelvis is accomplished by first bluntly dissecting the fat off the pubic rami until the external inguinal ring is identified. A 70 mm nasal speculum is then inserted into the external inguinal ring and the transversalis fascia is perforated. The blades are then immediately turned and driven cephalad (Figs. 45.8 and 45.9) without any further posterior motion of the speculum. When the blades are open one can feel fascia anteriorly and empty space posteriorly. We call this location posterior to transversalis fascia or PTF (Fig. 45.10). In patients with a compromised pelvis, the nasal speculum is placed inside the inguinal ring. Without perforating transversalis fascia the speculum is dropped and driven cephalad, thus perforating the roof of the inguinal ring. One must drive straight up behind the

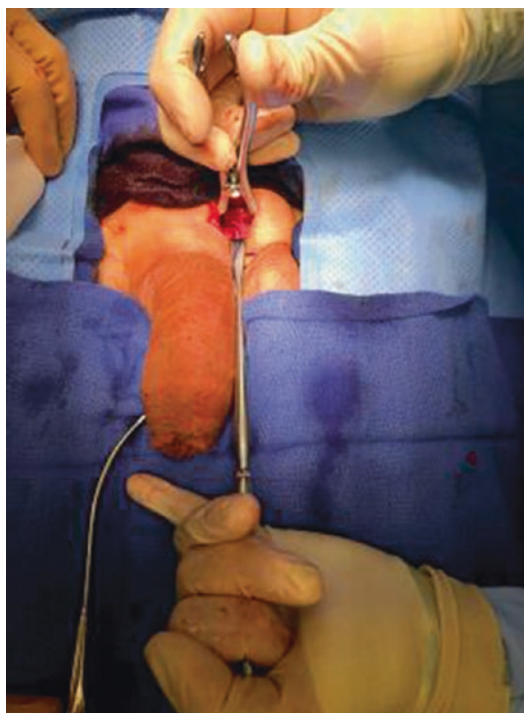
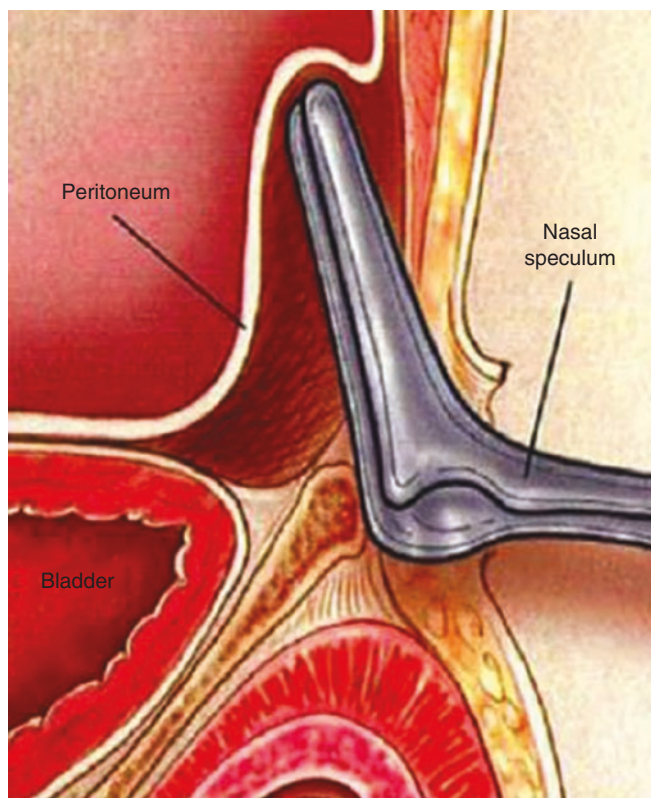


Fig. 45.8 Nasal speculum inserted into external ring

Fig. 45.9 Reservoir placed posterior to transversalis fascia in the uncompromised pelvis



rectus muscle strap. When you open the blades you will feel the rectus belly in front of your finger and the transversalis “drum” behind your finger. Because this is not a true anatomical space you must develop it with a 9 or 10 Hager. Because the patient is in the hyperextended position you should not enter the peritoneal cavity and should be able to place the reservoir high enough to not have it herniate in the immediate postoperative period. If you are using a Coloplast Coverleaf reservoir you will want to make sure the poppet valve is not compressed by tissue by removing the rubbershod after filling and pushing on the abdomen making sure no saline leaks returns back into the 60 cc syringe. If leakage is found, digital manipulation of the Cloverleaf reservoir should be enough to remedy the problem. We call this position anterior to transversalis fascia or ATF (Fig. 45.10). The identical position is beautifully described from a penoscrotal approach by Chung et al. colloquially called “high submuscular” [15]. A pediatric

Yankauer suction tip is then used to deploy the 125 cc reservoir cephalad (Fig. 45.11).

With our reservoir filled and our implant not yet delivered to the field, we drape off everything but the incision with antibiotic impregnated towels. The Keith needle is used for cylinder insertion. When deploying the Keith needle, one must always remember to again work along the long axis of the penis, which requires traction of the penis to keep the axis straight. Where the Keith needle comes out on the glans is not of much consequence as long as it comes out on the ipsilateral side because the implant will find the correct position. Both needles are passed before delivering the device to avoid inadvertent damage to the contralateral implant cylinder. In order to place the cylinder proximally, we like to pull the cylinder distally with the lead string maintaining tension on the string while holding the cylinder like a pen, draping the cylinder over the thumb. This allows the cylinder to act as a retractor, allowing a straight shot to drop the cylinder proximally. We make certain to fill any redun-

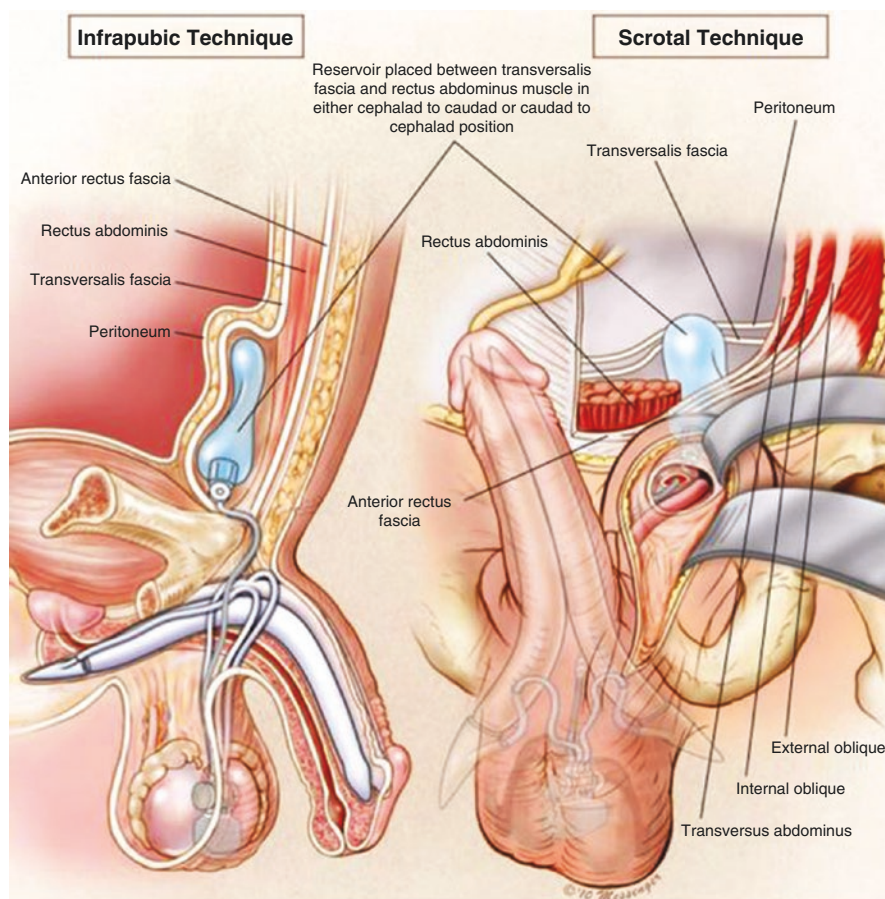


Fig. 45.10 Reservoir placed anterior to transversalis fascia in the compromised pelvis

dant cylinder into the corpora like an accordion. Some trainees prefer to drop the cylinder in proximally using a nasal speculum, first pushing down with a finger or the Yankauer suction tip or measuring device and then pulling distally (Fig. 45.12).

A rapid fill is then performed with a 60 cc syringe as a surrogate reservoir to evaluate the functional and cosmetic result. One may need to manipulate the penis back and forth to assist in correct cylinder seating. Any modeling can be performed now. The corporotomies are closed using the pre-placed stay sutures. The sutures are usually tied distal to the tubing exit site. If you still see implant cylinder, superficial closing sutures may be placed because they are only needed for hemostasis, not tunica integrity.

Pump placement is always midline, posterior and dependent – midline so you do not need to

worry about handedness, posterior so you do not see it and dependent so obese patients can find it. The pump is brought down along the same side as the reservoir using the nasal speculum to pop through Colles' fascia deep into the most dependent portion of the scrotum. The blades of the nasal speculum point to where the pump will reside (Fig. 45.13). The assistant takes the pump in an anterior-posterior fashion and firmly pulls down until the dartos fascia is felt to release, resulting in perfect pump placement (Fig. 45.14). Proper pump position is confirmed by pulling up on the penis or our "pump test" (Fig. 45.15). If the pump remains in the dependent position, the patient and patient's partner should be satisfied. If the pump rides up it will certainly ride up on the partner during sex and this is usually associated with visible tubing. The pump is then pulled



Fig. 45.11 Deploying the 125 cc reservoir with the use of the pediatric Yankauer



Fig. 45.13 Using the nasal speculum to pop through Colles' fascia deep into the most dependent portion of the scrotum for pump placement

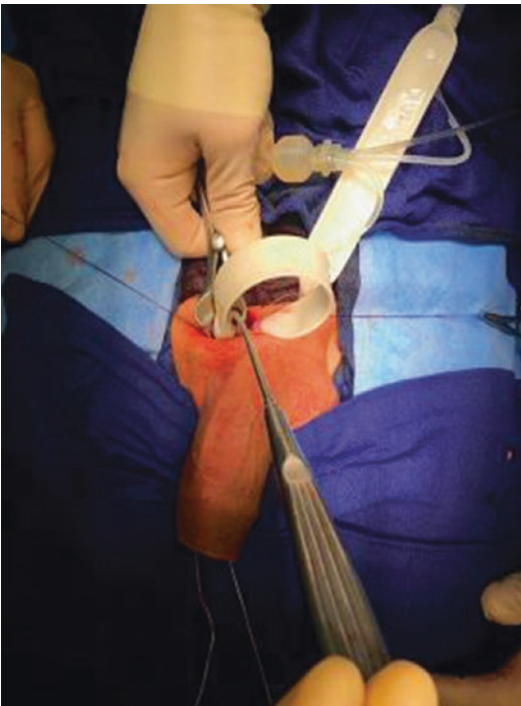


Fig. 45.12 Cylinder placement proximally



Fig. 45.14 The assistant grasps the pump in an anterior-posterior fashion and gently pulls down until the dartos fascia is felt to release, resulting in perfect pump placement



Fig. 45.15 Confirming correct pump position by pulling up on the penis or “pump test”



Fig. 45.16 Drain placement

up to the mid scrotum for easy tubing connection between the reservoir and the pump. When placing a Coloplast Inflatable, we still use the original genesis pump because of its' low profile (only 10 cc displacement). To date, no pump has “stuck,” a problem seen only in pumps with one-touch capabilities. When the pump is returned to the dependent portion of the scrotum no residual tubing remains at the incision site.

Finally, a #10 Jackson-Pratt surgical drain is placed along the entire length of the surgical field adjacent to the implant (Fig. 45.16). The end of the drain is brought out through a separate stab wound superior to the incision. Scarpa's fascia is closed with a running suture. Staples are used to close the skin, as the staples tend to deter patients from touching their surgical wounds. A Tegaderm™ is used to dress the wound. Compressive dressings are not utilized. A 10-pound sand bag is placed on the incision for 2 hours in the recovery room. Once the sand bag is removed, the drain output is monitored over the next hour. If a brisk amount of drainage is documented (>60 cc/hr), the sand bag is reapplied (Fig. 45.17).



Fig. 45.17 A 10-pound sandbag applied to incision for 2 hours in the recovery room

45.4 Post-operative Care

All our patients have drains post-operatively which are removed sometime between 1 and 3 days out. Expected output is somewhere around 100 cc of drainage within the first 24 hours. If the drainage has dropped off over the previous 4 hours, the drains are usually ready to be removed post-operative day #1. Patients are discharged home on NSAIDs. Any pain warranting opioids should be further investigated. No outpatient antibiotics are prescribed. Patients must not submerge in water until the wound is completely sealed.

The patient is immediately instructed to pull down on the pump and attempt to find the deflate mechanism every time he voids. This expedites the teaching process and is made possible because of the absence of an incision on the scrotum. This also helps to disperse the inflammatory tissue always found around the newly placed pump. During the first 2 weeks after implantation patients are told to practice deflating the implant from front to middle to back whether they are cycling the implant or not. Implants are cycled as soon as the patient can tolerate the process and patients are encouraged to engage in sexually activity sometime after 2–3 weeks.

45.5 Post-operative Complications

Immediate post-operative urinary retention is seen in approximately 4% of our patients undergoing penile implants using the infrapubic approach. If patients are discharged the same day of surgery, they must void before they leave the facility otherwise they undergo straight catheterization which is usually enough for them to last overnight if they do have prolonged retention. As with for our penoscrotal counterparts, our most frequent postoperative complaint is scrotal pain. However, in the case of the infrapubic approach this is almost exclusively related to

tubing running down the affected side and resolves prior to post-operative day #14 which is our target date for initial cycling and use. Regarding the potential for a dorsal nerve injury during infrapubic placement of a penile prosthesis, we have performed more than 6000 cases with more than 400 visiting urologists accompanying our team and we have yet to document one case of penile sensory loss.

Distal urethral injuries were not uncommon in our early years because we did not focus on protecting the fossa during measurement with the Furlow. Our current technique of protecting the fossa by squeezing the glans with a 4 × 4 gauze pad for increased stability has decreased the rate of distal urethral injuries to zero on virgin cases. This portion of the procedure was further improved upon by gently bouncing the Furlow down the penis during measurement, never allowing the device enough velocity to overcome your protections. Our bowel, bladder and vascular injury record for reservoir placement has stood test of time using the aforementioned techniques [16]. However, recently Gross et al. demonstrated that patients with low BMIs should be more cautiously monitored for inadvertent intraperitoneal placement of the reservoir using ATF or PTF placement of the reservoir [17]. Finally, our infection rates are routinely less than 1% yearly with diabetics demonstrating no difference from non-diabetics when pre-operative blood glucose is less than 200 mg/dl.

45.6 Conclusion

Any approach to a penile implant by a dedicated surgeon with a dedicated team should result in a safe and efficacious result down the road for your patient. We have entirely adopted the minimally invasive infrapubic approach to penile implantation because we believe it is “patient friendly” and leads to a rapid return to a normal sex life.

Key Summary Points

- With careful positioning, infrapubic penile prosthesis placement is appropriate in all patients seeking surgical intervention for erectile dysfunction.
- An artificial erection at the beginning of the procedure allows the surgeon the opportunity to address corporal pathology before placing the cylinders and precludes the use of serial dilation during IPP placement when there is no significant corporal pathology.
- The infrapubic incision allows for safe and rapid insertion of the penile prosthesis reservoir with reduced risk of bowel, bladder and vascular injuries.
- Midline, posterior and dependent placement of the pump is essential for patient satisfaction following IPP placement.
- The absence of an incision in the scrotum and the use of negative pressure drains expedite the rehabilitation period following IPP placement.

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Penile Prosthesis Implantation in Complex and Previously Failed Settings

46

Sevann Helo, Jonathan Clavell-Hernandez,
Steven K. Wilson, and Tobias S. Köhler

46.1 Introduction

Most prosthetic surgeons would agree that a patient's first implantation surgery offers the highest likelihood of success. Dr. John Mulcahy opines that *"The penis gets shorter with each operation and the patient unhappier."* Nevertheless, despite being the least likely to need a revision of all the medical devices implanted into humans [1], a distinct chance remains that a reoperation will be necessary. The most common reasons for revision surgery include mechanical failure, followed by patient dissatisfaction [2–5]. Long-term data regarding mechanical failure demonstrates 96% survival at 5 years, 80% survival at 10 years, and 70% survival at 15 years for inflatable penile prosthesis (IPP) implantation [1, 6]. It is important to review these figures when counseling patients preoperatively, particularly younger patients who will

likely require a revision surgery for device failure within their lifetime. The most common cause of mechanical failure is a fluid leak from the device, while supersonic transport deformity, aneurysm of the cylinders, impending lateral extrusion, and desire for upsizing the cylinders are additional reasons for revision surgery [7].

While revisions for mechanical failure and patient dissatisfaction are relatively routine surgical procedures, penile prosthesis implantation in previously failed settings is daunting, even for the experienced implanter. The surgical planes are altered and obliterated by scar. To maximize success, specialized instruments, downsized implants and lots of experience are necessities. Even experienced implanters without these assets have only a 50% chance of success. Even if a surgical victory is achieved for the surgeon, the patient may be unhappy about his loss of length.

Our senior author has 45 years of experience with thousands of reoperations and reinsertions. Many of his recommendations outlined in this chapter have never been published. This chapter is meant as a guide to the focused implanter for navigating the tricky pathways of redo of multi component prosthetics. We hope to help the reader prevent mistakes and reward realistic patient expectations in this difficult surgery on discouraged patients. To facilitate your learning of essential caveats and previously unpublished ideas regarding this complex prosthetic surgery, we have used bold print to illuminate them.

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46.2 Preoperative Evaluation

The initial consultation is an opportunity for the prosthetic surgeon to gather as much information as possible regarding the patient's medical comorbidities, previous surgical history, physical exam, and expectations for their revision surgery. We would advocate a **“plan for the worst, hope for the best”** approach as many of the most common challenges can be anticipated upon preoperative work up.

46.2.1 Imaging

It is strongly recommended that every effort be made to obtain the patient's operative report if the previous surgery was performed by another surgeon. The operative report provides the roadmap to their initial surgery including surgical approach, type of device used, cylinder size, use of rear tip extenders, location of reservoir, and intraoperative complications. This becomes increasingly important in cases where patients have undergone multiple revision surgeries. In situations where it is not possible to obtain the patient's operative report, we would advocate obtaining either a computed tomography (CT) scan or magnetic resonance imaging (MRI). Typically, **a CT scan will provide all the information needed including location of the reservoir and presence of rear tip extenders.** In patients who have undergone multiple revision surgeries, a CT scan may demonstrate a defunctionalized reservoir on the contralateral side of the current reservoir that was left behind in a “drain and retain” situation. A CT may also demonstrate an unexpected location of the current indwelling reservoir (Fig. 46.1). An MRI is rarely indicated as it is costlier and more difficult to obtain, but can provide a greater level of detail of the corporal bodies in cases of impending erosion, particularly when the indication for revision surgery is unclear based on history and physical exam.

46.2.2 Physical Exam

In addition to a thorough history, the physical exam provides invaluable information that can

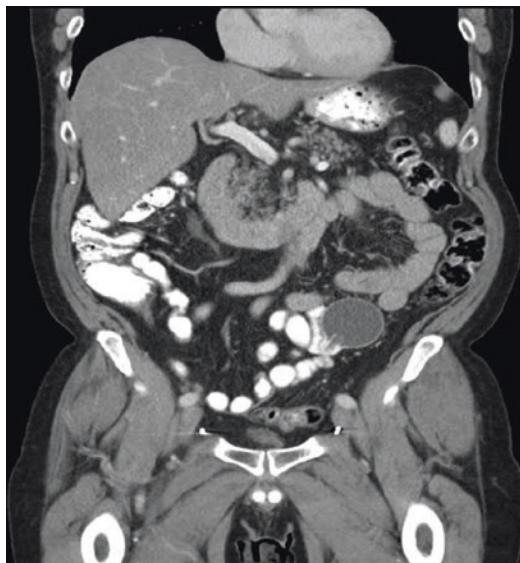


Fig. 46.1 Pre-operative CT scan demonstrating intra-peritoneal IPP reservoir

help in operative planning. We recommend the patient be examined in the supine position and in the frog leg position. Careful palpation at the level of the proximal corporal bodies after a recent explant for infection may reveal cement like fibrosis preparing the surgeon for the need for special instruments. Similarly, post priapism patients often will demonstrate very scarred distal corporal bodies that are easily palpable. Scars from previous surgeries are typically visible in the lower abdominal and scrotal areas, particularly if an infrapubic approach was used. The site of the exit tubing is also typically palpable in the infrapubic approach, especially in thin patients. In situations where either a horizontal infrapubic, or midline vertical lower abdominal incision is visible but exit tubing is not palpable, the incision may represent a counterincision used for reservoir placement rather than the cylinders themselves. Surprisingly enough, the patients are frequently no help in telling you where the incision was made! IPP revisions occur years after the original implantation and patients simply forget. Accessing the corporotomy site at the level of the exit tubing in an infrapubic IPP can be more challenging from a penoscrotal approach, therefore the surgeon may consider using the

same approach used to place the original device to provide more direct access to remove all of the components. This may not be true in the setting of infection in which case it may be advisable to use a penoscrotal approach where there is less scar tissue from a previous implant placed using an infrapubic approach.

There is always the danger of damage to the dorsal nerve of the penis in reoperations done through an infrapubic incision. The anatomy is not so clear in return operations as it was in the virgin implantation. In our experience, **the pump and cylinders of an infrapubic placed device can be completely extracted via scrotal incision, including the tubing boots on American Medical Systems (AMS) devices.** The authors commonly make corporotomy distal to tubing exit and remove the cylinder, boots and tubing retrograde by a forceful pull of the cylinder body. If the reservoir must be removed e.g. infection, a separate abdominal incision must be made but there is no danger of dorsal nerve injury from this incision.

Attempts to cycle the device will generally provide useful information in all cases requiring revision. Fluid leak in the system is obvious as air causes turbulence as it cycles through the pump. “Sticky pump syndrome” is demonstrated by difficulty inflating or deflating the device [8]. If the indication for revision is patient dissatisfaction, cycling the device provides an opportunity to discuss the patient’s grievances and expectations including location of the pump, palpable exit tubing, device sizing, floppy glans, supersonic transponder (SST) deformity, and pain with inflation.

New onset urinary symptoms after IPP warrants evaluation with urinalysis, pressure-flow study, post void residual, and cystoscopy to rule out erosion. Cystoscopy usually demonstrates external compression of the bladder due to the reservoir, particularly in patients with large cylinders that require a larger volume reservoir. This is of no consequence to a knowledgeable implanter unless the surface of reservoir is visible. This distortion may also be noted on CT imaging where the bladder is displaced medially due to a large reservoir. CT should not be considered as a substitute for a cystoscopy to rule out erosion.

Additional considerations include external compression by the exit tubing or pump relative to the urethra in cases of obstructive urinary complaints.

46.2.3 Patient Counseling

Setting realistic patient expectations is critical to patient satisfaction. Prosthetic surgeons should have a thorough discussion with the patient regarding what to expect in the perioperative course including post-operative recovery time, risk of infection, and penile length.

In our experience, patients typically report a shorter recovery time than their initial surgery, likely because less dissection is required as the corpora have previously been dilated. They should be counseled about the potential need for a counterincision to remove the old reservoir in the case that it cannot be retrieved through the primary incision or in the event that the reservoir had been placed in an abdominal wall location.

The risk of infection in revision surgery is an important discussion point during preoperative counseling, particularly in patients who are dissatisfied due to a minor imperfection, but in whom the device is functional. The decision to hastily proceed to the operating room for revision of a device due to pump location, palpable or visible tubing and other aesthetic considerations should be avoided as it is likely not worth the risk of an infection. Depending on the nature of the patient’s complaint, a trial period of 6–12 months should always be urged prior to scheduling the patient for revision surgery as the patient may be more willing to accept certain imperfections over time. Our senior author’s admonition is **“never rush to revision.”**

Patients should be counseled that **the risk of infection increases with each subsequent revision surgery** from less than 1% with primary implantation surgery to a rate of 8–18% with revision surgery [9–13]. Contemporary studies have demonstrated a benefit to using a washout protocol in revision surgery of a clinically uninfected and noneroded prostheses with a reported infection rate of less than 3% in cases where all

components of the prosthesis were removed and the implant space washed out with an irrigation protocol [6, 14, 15]. We have moved away from the use of betadine and hydrogen peroxide as irrigation solutions instead using only copious antibiotic irrigation. Both betadine and hydrogen peroxide are tissue toxic and our group has demonstrated a remarkable nine fold increased infection risk for all implant cases (revision and virgin cases) using betadine irrigation with antibiotic irrigation versus just antibiotic irrigation alone (AUA abstract). Despite remarkable improvements in “first time implant” infection rates, a retrospective review of 44 patients presenting for IPP revision surgery to the Mayo Clinic had an increased rate of infection which correlated to how many revision operations they had undergone in the past [16]. As demonstrated in Fig. 46.2, as the number of previous IPP operations increased, the higher the risk of device infection. When the patients reached 4 revisions they had a 50% prevalence of having had an infection and on the 5th revision they had at least one IPP infection in their history.

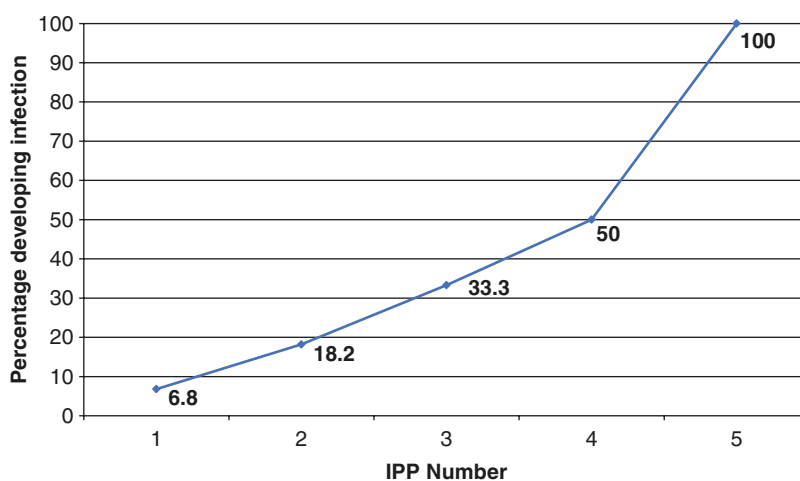
Penile length is a common concern in IPP surgery, both in the primary and revision settings. Patients who have an IPP that is correctly sized and in place at the time of revision, can expect at the very least to maintain their current penile length. Typically, the implant space within the corpora will accommodate a slightly larger device than their previous cylinder size, allowing

for upsizing of the device at time of revision. However, despite longer cylinders, the patient typically does not note a clinical length difference but may notice an increased girth if the new device allows for greater lateral expansion. **Appreciation of improved penile girth is noted commonly, if an AMS cylinder is removed and a Coloplast cylinder substituted.**

Patients in whom the device was explanted due to infection or erosion no longer have an implant in place. They can expect loss of length, sometimes to a devastating degree. The corpora of these patients are typically fibrotic and may be difficult to dilate, particular in post-infection cases. Patients who are likely to have corporal fibrosis due to history of prolonged ischemic priapism, diabetes, Peyronie’s disease, trauma, or intracavernosal injection therapy for erectile dysfunction should also be identified and counseled accordingly in the preoperative setting [17, 18] *“We will give you a functional device, but it will not look or perform like it did before you had the infection.”* This discouraging news, however, can be tempered by these words. *“After 8-12 months of a daily inflation protocol, the device will act as a tissue expander. The cylinders will be too short and too thin. Then we can go back in and place a longer and wider cylinder.”*

Patients with a functional IPP in place, who are pending revision surgery for this upsizing, should be advised to inflate their device daily to the point of discomfort and leave it inflated for

Fig. 46.2 Percentage of patients developing an infection with most recent device based on the IPP device number (Pearson Correlation Coefficient $R^2 = 0.90$, $p = 0.01$). As an example, 50% (4/8) of patients on their 4th IPP revision in this historical series developed infection. (Adapted from Ref. [15])



several hours. This regime will assist in maximizing penile length and girth [19]. Those who do not have a penile implant in place should be encouraged to use a vacuum erection device daily for at least 7 weeks preceding surgery in an effort to expand the improve tunical compliance, influence the intracavernosal space, possibly impact the fibrosis development, and facilitate easier dilation at the time of IPP surgery [20]. Penile stretching devices may also have a role in maximizing penile size pre-procedure.

46.3 Challenging Cases

46.3.1 Corporal Fibrosis

Corporal fibrosis is a process that involves excessive deposition of scar tissue in response to infection, trauma, or ischemia [21]. It does not occur merely as a result of previous IPP surgery. In other words, **routine removal of an implant for reasons of mechanical problems, physician error or patient dissatisfaction does not result in the development of fibrotic scar tissue in the space previously occupied by erectile tissue.** These scarred corporal bodies may result from disease processes such as diabetes, Peyronie's disease and arterial insufficiency. The development of corporal fibrosis is certain after extraneous and disastrous events such as priapism or the development of a device infection.

46.3.1.1 Infection

The most severe cases of corporal fibrosis occur after removal of an infected penile prosthesis, and are associated with significant penile shortening [22, 23]. Fibrosis secondary to infection is more common in the proximal corpora, making proximal dilation challenging. Dr. Karl Montague first advocated use of a transverse scrotal incision rather than vertical scrotal or infrapubic for allowing better access to the proximal corpora in difficult cases. We also recommend a generous transverse scrotal incision to maximize proximal exposure. Careful dissection to make the corpora "squeaky clean" where the lateral borders of the corpora are easily demonstrated should be undertaken. This sometimes requires clearing of tissue adherent to the corpora in the distal penis where a virgin plane is easily located. Pre-placed stay sutures both proximally and distally to the point of intended corporotomy facilitate finding the proper intracorporal space. Distal dilation should be undertaken first and is typically not too difficult. If any resistance is felt with distal dilation (more likely after priapism), extension of the existing incision or additional corporotomies should be placed. A distal counter incision is advisable in distal difficulty as the urethra is easily damaged by blind passage of small sharp instruments. **Sometimes it is advisable to make the second corporotomy just under the glans so that this dilatation can be performed under direct vision** (Fig. 46.3).

Fig. 46.3 Never be afraid to make the second incision. The urethra is easy to lacerate when dilating distally from the proximal corporotomy. With the second incision, the dilatation is basically under direct vision



Care should be taken during dilation to direct the dilator away from the urethra while avoiding unnecessary force to prevent perforation. Next the distal measurement should be performed to estimate the remaining proximal distance (knowing previous total implant size) that may be required. Depending on the degree of fibrosis, sometimes making a cruciate puncture of the proximal corporal space with a #15 scapel blade (or alternatively Metzenbaum scissors) is needed to start the downward dissection away from the urethra between the undersurface of the tunica and the fibrotic area [24, 25]. Some advocate some scar tissue removal to facilitate corporal closure. Trans-corporal resection using a 26-French resectoscope with loop has also been described as a means of corporal excavation [26]. **We have had good results resecting the tissue by taking an electrosurgical pencil and bending the tip creating a surgical loop similar to the one used for TURP.** The current is #1 Cut at 35 watts (Fig. 46.4).

Careful proximal serial dilation should be undertaken starting with a small dilator (6 Uramix or 8 Carrion Rossello) again erring laterally in an attempt to find the ischial tuberosity. The downside of using a small dilator is its propensity to perforate proximally where even experienced implanters have about a 50% proximal perforation rate. Suture slings as described by Wilson are commonly required (Fig. 46.5) [27]. Prior to making the initial corporotomy in a case with corporal fibrosis, the surgeon is miles ahead by

first exposing the proximal corpora surface. This will facilitate proper instrument passage proximally as it will be under direct vision instead of blindly estimating the direction of the proximal corpora. Our senior author has excellent videos on the Video Journal of Prosthetic Urology web site showing how this maneuver is easily accomplished with sharp dissection and the insertion of two baby Deaver retractors (www.vjpu-issm.info) (Fig. 46.6).

This dissection and exposure of the entire proximal corpora reap benefit to help the surgeon locate the proper plane. Occasionally, one side is easily discovered and the other a challenge. Thus, if there is any doubt about the correct downward direction of the corpora on the first side, the other side should be attempted. Once the proper direction is found on one side, a dilator left in situ will help the surgeon find the other by comparison.

If proximal dilation is achieved with a 12 brooks dilator, a standard size device can be placed. **Any hitch or resistance with a 12 brooks dilator should prompt the surgeon to use a narrow cylinder.** Metal dilators are non-compressible and thus can find a way beyond a point of narrowing, while the proximal portion of the implant or rear tip extenders will accordion and will not seat properly. **It is important in these fibrotic cases to exit the corporotomy at the junction of tubing and cylinder. If the tubing is in the proximal corpora as in most virgin implants, dilatation to more than 10 for a nar-**

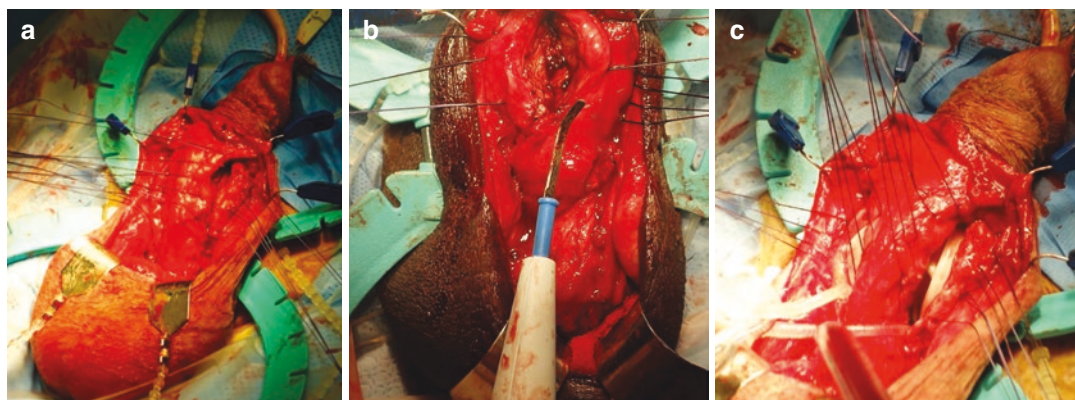


Fig. 46.4 (a) Extensive corporotomy, like “the belly of a fish”. (b) Corporal excavation with electrosurgical pencil. (c) After excavation multiple stay sutures easily tied

Fig. 46.5 Illustration of Rear Tip Extender Sling of non absorbable suture for proximal perforation

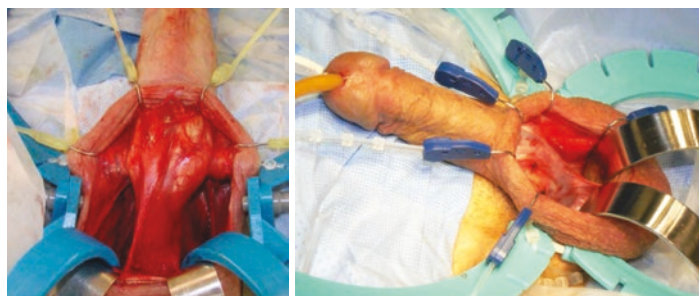
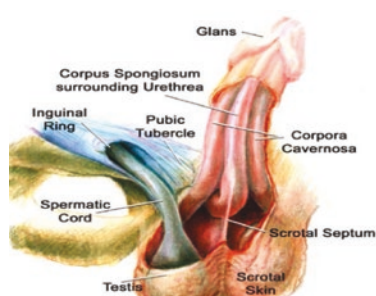
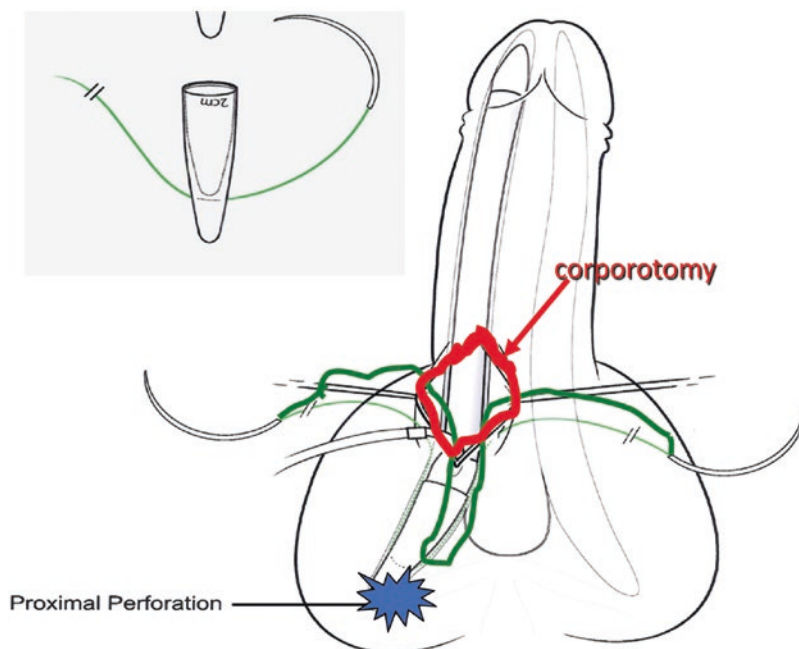


Fig. 46.6 Demonstration of dissection of proximal corpora to facilitate proximal corporal dilatation. A video of this maneuver is available on www.vjpu-issm.info. Video is entitled “The Tunnel Technique”

row base cylinder will be necessary. This, of course, is impossible in these difficult cases. **To avoid burying the tubing, it is necessary to build up the base of cylinders used in reinsertion into scarred corporal bodies with rear tip extenders (RTE).** The surgeon can remember that the base of the narrow cylinder is 4 cm for both AMS and Coloplast devices, prior to reaching the input tubing juncture. A cylinder size must be chosen that allows the surgeon to add enough RTE to reach the measurement from corporal base to proximal beginning of the corporal incision. If the cylinder tubing is forced into the proximal corpora, this leads to inability to close

the corpora, unnecessary pressure on the exit tubing often leading to inability to deflate the device, or folding of the cylinder fabric, a future area of weakness where the device might rupture.

We have needlessly struggled countless times when trying to place a standard device in this situation. **It is not an admission of defeat to place a narrow cylinder. In our opinion, the best cylinder size for these difficult reinsertions is the Coloplast 16NB. This “downsized” cylinder when inflated is very close to the girth of a standard AMS 700 CX.** The Coloplast 14NB and AMS 14, 16 CXR expand to a girth that is less generous. Clinical appearance of the penis is

initially excellent even with narrows because of the stenotic corpora. With usage the device acts as a tissue expander lengthening and expanding girth of the scarred corpora. If the patient is dissatisfied, he can be assured that the downsized cylinders will accomplish preparation of the space for a standard size device for the next revision.

Timing to reimplantation is one of few modifiable factors to minimize the extent of fibrosis after infection. **Reimplantation within 16 weeks**

allows sufficient time for the infection to be adequately treated, and it may be easier to identify the old corporal cavity before it becomes obliterated. A patient pending reimplantation after penile prosthesis infection should be advised to use a vacuum erection device for at least 10 minutes twice daily. Maximum stretching of the penis occurs typically by 7 weeks [20]. Figure 46.7 demonstrates a potential sequence following implant removal for infection.



Fig. 46.7 (a) Small shrunken penis after removal of infected IPP. (b1) One year after Coloplast 11 + 5NB; SST has occurred (b2) pulling on shaft skin demonstrates cylin-

der too short. (c) Removal of downsized implant; note stacked RTE to facilitate insertion into proximal corpora. (d) Replacement result; 16 + 2 Standard Titan cylinder

46.3.2 Priapism

In contrast to corporal fibrosis associated with infection, the fibrosis encountered after priapism is most pronounced distally. While still challenging, IPP surgery in this setting is generally easier than in the post-infection cases. In contrast to the traditional transverse penoscrotal incision, a vertical midline incision is useful along the raphe with plans to extend the incision as far distally as needed for adequate exposure. **Brooks dilators are preferred over Hegar dilators** because instrument resistance is higher in response to narrowing. This is because the circumference of the dilator is the same over the entire length of the Hegar.

Distal dilation should never be forced, as small dilators easily find their way into the urethra. In this instance, the case should be aborted and a catheter left for only 1–2 days. **If the urethra is damaged distally, resist the temptation to leave the Foley longer than 48 hours as this may cause stenosis of the fossa navicularis. The urine does not need to be diverted from the urethral laceration because it is so distal.** Generally, implantation can be re-attempted after negative cystoscopy (typically 4–6 weeks after injury). If resistance is met during distal dilatation, extend the corporotomy. **Each time the corporotomy extended 2–3 cm, place another set of stay sutures to give good traction against which to pass the instruments. Occasionally it is necessary to open up the entire corpora like the belly of a fish** (Fig. 46.6). It is sometimes useful to excavate the corporal tissue. Several techniques have been described in the literature [22, 23, 25]. **It has never been published but we find it useful to use the electrosurgical pencil to resect a larger channel to facilitate closure of the tunica over the cylinder** (Fig. 46.3). The use of additional stay sutures and distal extension of the corporotomy is always the safest way to progress. Blind poking of sharp instruments from the original proximal corporotomy traversing the long distances in the distal corpora should be avoided.

If a transverse penoscrotal incision was used, and attempts at dilatation distally are unsuccessful, a transverse subcoronal incision at the point

of maximal resistance should be made to allow for a separate distal corporotomy to be made. This allows for dilatation of corporal fibrosis under direct visualization. Some surgeons will start distally and work backwards to meet up with the corporotomy to prevent urethral injury. Excavation of distal tissue is rarely necessary given the compressibility of the distal cylinder and the ability to pull on the implant threads as they are pierced through the glans. Caution should be taken in cases where the patient has undergone a distal corporoglandular shunt, as the risk of distal perforation may be increased. After distal shunt, we prefer inflatable devices and restrict inflation for 6 weeks after the procedure. If a malleable device must be used in this instance, it should be undersized and affixed with a permanent suture through the device and corpora.

Time to implantation after an episode of ischemic priapism depends on several factors, namely patient preference and extent of treatments used to manage the episode of acute priapism. Given the time-dependent risk of irreversible corporal fibrosis, a delayed presentation of ischemic priapism warrants a thorough discussion with the patient as to the risks of initiating a pathway of corporal irrigation and shunting versus proceeding immediately to IPP. Corporal irrigation and distal shunting increase the risk of infection and erosion if the patient ultimately elects to proceed with penile implant in the short-term and are unlikely to be successful in patients presenting with continuous ischemic priapism for greater than 24 hours. Some authorities choose to decompress priapism by using dilators via a penoscrotal approach as if an implant were being placed facilitating future prosthesis placement [28].

A study of 23 patients who underwent MRI and biopsy of the corpora demonstrated that MRI had 100% sensitivity in predicting nonviable smooth muscle during an episode of ischemic priapism and may therefore be a useful tool when counseling patients [29]. In patients found to have extensive nonviable smooth muscle on MRI at time of presentation, proceeding directly to penile prosthesis may facilitate quick recovery and preserve penile length compared to elective surgery after the erectile dysfunction is observed

[30]. For patients who have undergone instrumentation, waiting approximately 3 weeks may allow sufficient time to recover from the bacterial inoculation by the previous instrumentation, but prior to the development of extensive corporal fibrosis [31, 32]. **Most important, similar to reimplantation after infection, reoperation within 16 weeks makes identification and dilatation of the corpora channel easier as opposed to a longer interval of time during which the space can become completely obliterated.**

46.3.3 Tools for Stenotic Corpora

46.3.3.1 Cavernotomes

Rather than excavate corporal tissue, cavernotomes can be used to drill through fibrous cavernous tissue. There are two types of cavernotomes available, the *Carrion-Rossello* (Coloplast Corporation, Minneapolis, MN) and the *Uramix* cavernotomes (Uramix, Inc. Lansdowne, PA, USA). The Carrion-Rossello cavernotome is available in stainless steel and is sized from 8 mm to 12 mm. The instrument is configured like a bayonet rasp with small sharp teeth-like projections from the sides of the device [33]. It functions to create a tunnel like a wood rasp by consecutive movements of pronation and supination of the hand. The projections allow the cavernotome to progressively break through the fibrotic tissue while preventing a sudden forward uncontrolled movement that could lead to inadvertent urethral injury [22]. The Uramix cavernotome is available in stainless steel, sized from 6 to 13 mm and is 23 cm in length. Unlike the Carrion-Rossello, which has circumferential projections, the Uramix cavernotome has a single or double beveled surface with a longitudinal blade(s) that allows for 1 mm shavings of tissue to be resected. It can be used to cut through fibrotic tissue in a longitudinal, up and down movement, or in a “drilling” rotational movement [34]. The blade(s) of the Uramix cavernotome should always be directed away from the urethra. While both cavernotomes can be effective at creating a space within fibrotic corpora, the authors of this chapter **prefer to use Uramix cavernotomes distally because of their**

smaller initiation size. After the space is initiated proximally, the Rossello cavernotomes are preferred because the bayonet configuration allows additional pressure to be applied in advancing it. With both these devices we caution the surgeon to avoid what Wilson calls a QBM. That stands for “quick birdlike movement” ... usually accompanied by “Oh Sh...” Steady oscillating movement rather than jabbing claims the victory. **When in doubt or encountering resistance ... enlarge the corporotomy add another set of stay sutures and try again.** There is also a line of expert instrumentation for advanced prosthetic urology available through Sontec Instruments (Denver, CO, USA) including a special heavy-duty titanium scissors that can cut in the traditional manner, as well as sharpened blades along the outside that allows for reverse cutting when the scissor blades are spread in dense tissue (Fig. 46.8). In our opinion, a set of backward cutting scissors is very rewarding for opening enough of a space to engage the cavernotomes. In addition, they can be very useful for cutting a difficult localized stenotic band by simply



Fig. 46.8 Wilson reverse cutting scissors useful for establishing a space for cavernotome to operate within during implantation of cylinders into scarred corporal bodies. (Sontec Instruments® Centennial CO)

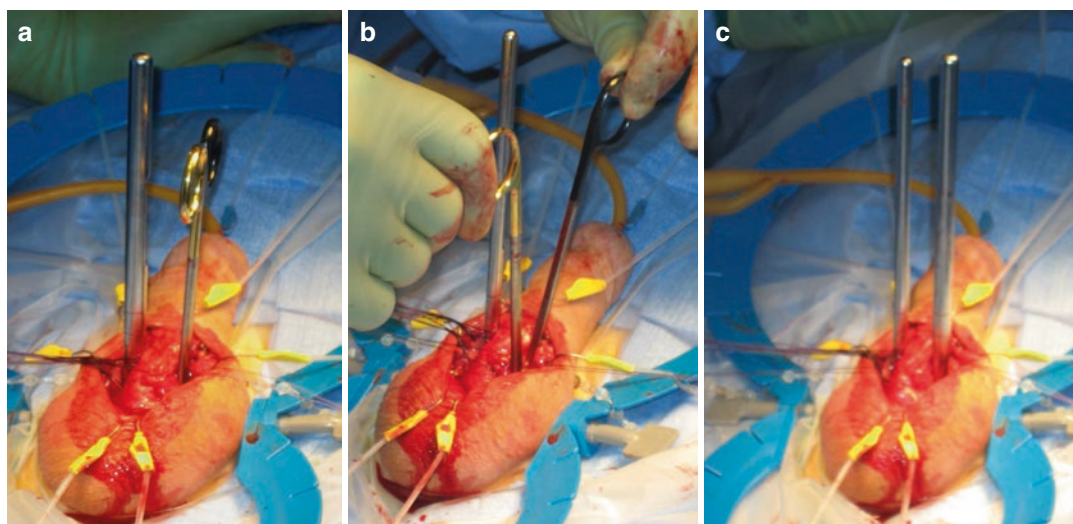


Fig. 46.9 (a) Patient's right side dilated. Using cavernotome as a direction guide, backward cutting scissors advanced forcefully to ischial tuberosity. (b) Scissors

spread repeatedly coming out to cut tunnel. (c) goal post test to confirm correctness of proximal dilatation

inserting the scissors in the opening and then forcefully opening then ... the backward cutting blades incise the stenosis (Fig. 46.9).

46.3.3.2 #12 Blade Scalpel

For larger, areas of dense scar tissue resistant to dilation with a cavernotome, a nasal speculum may be inserted through the corporotomy and a #12 scalpel, a.k.a. hook bladed knife, is used to cut through the tissue. The curved tip of the #12 blade should be directed away from the urethra when incising tissue to prevent inadvertent urethral injury.

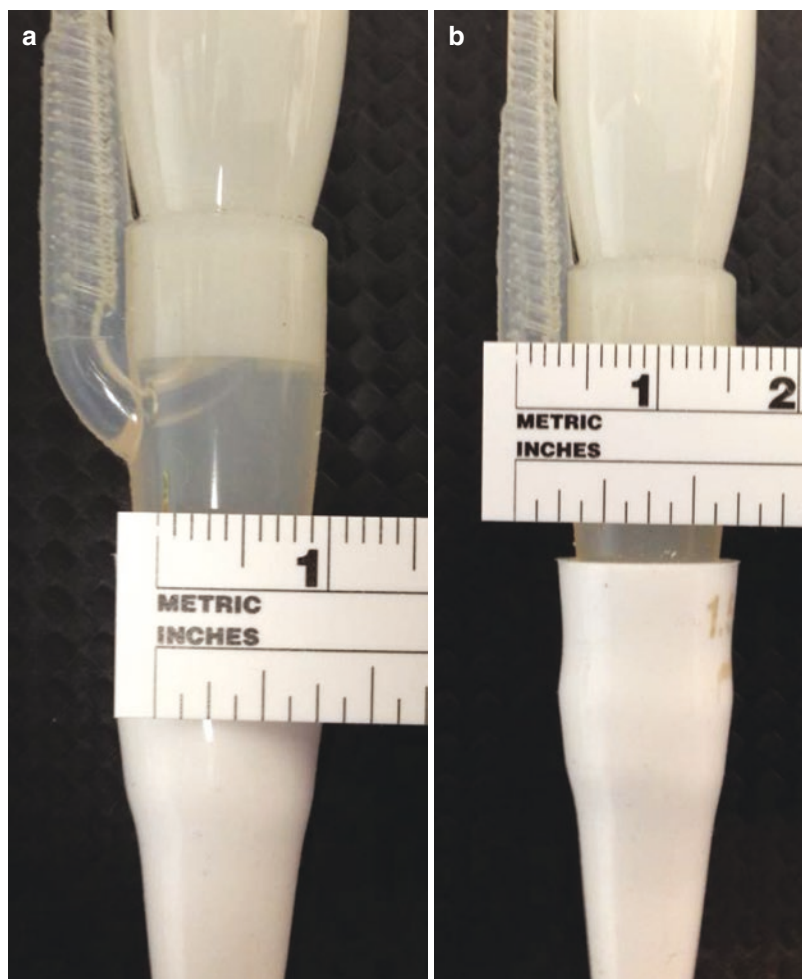
46.3.3.3 Narrow Base Cylinders

In patients who have a long segment of narrow stenotic corpora and whom corporal excavation, fibrosis incision or dilation with cavernotomes is insufficient to accommodate a standard cylinder, alternative girth cylinders exist. Both AMS and Coloplast offer narrow cylinder devices (AMS 700 CXR and Coloplast Titan narrow base (NB)) that are approximately 9 mm in the non-expanded state and expand to a girth of 14 mm (AMS) and as much as 17 mm (16 NB and longer). Use of one of these narrow cylinders requires dilation up to 10 mm for the AMS 700 CXR and 9 mm for the Coloplast NB within the proximal corpora

cavernosa to allow their insertion, in contrast to 11 or 12 mm required for a standard cylinder. **Distal dilatation to 9 is required for insertion of the Furlow instrument to advance the tip of the cylinder.** The AMS 700 CXR is available in 12, 14, 16, and 18 cm cylinders while the Coloplast NB is available in 11, 14, 16 and 18 cm cylinders. The Coloplast NB offers an advantage of a zero-degree tubing exit from the base of the narrow cylinder. In addition, if one can utilize a 16 NB rather than a 14 cm cylinder the resultant girth is much better. The expansion in girth of the 16 and 18 NB is almost as large as a standard AMS 700 CX cylinder. **As surgeons who must listen to the patient's complaints 1 year after the tissue expansion caused by usage of down-sized prosthetics, we strive valiantly to place the 16 NB as it may obviate the need for additional upsizing reoperation.** If we have performed the additional exposure of the proximal corpora described above (Fig. 46.6) we can generally extend the corporotomy proximally to use less RTE and still exit the tubing from the corporotomy.

To emphasize our very important point on cylinder sizing in difficult cases, it is worth mentioning once again. The series of Boston Scientific standard sized cylinders requires dilation to 11 mm,

Fig. 46.10 (a) Measurement of true base of cylinder with RTE. (b) Measurement of base of cylinder & input tubing



with the ability to add as much as 7.5 cm of rear-tip extenders (RTE), while the standard Coloplast cylinders require dilation to 12 mm with the ability to add 6 cm of RTE. **In cases of severe proximal corporal fibrosis, the surgeon is advised to use the maximum size RTE with the shorter size of cylinder so that the cylinder tubing exits the corporotomy rather than lying adjacent to the base of the cylinder within the proximal corpora.** For example, if the combined measurements were 20 cm, rather than use a 20 cm Coloplast cylinder, the device should be sized as a 16 cm cylinder with a 4 cm RTE. If using a Boston Scientific device, a 15 cm cylinder with a 4 cm RTE should be used rather than an 18 cm cylinder and 2 cm RTE.

Attempts to bury the tubing in the corpora will increase the diameter of the base to 15 mm

or more even with a narrow base cylinder (Fig. 46.10). In cases of proximal fibrosis, the input tubing may be compressed and prevent deflation of the device if forced into a stenotic space. If this problem is recognized at the time of surgery, use of a blunt-tip electrosurgical pencil on #1 cutting current electrocautery (≤ 35 watts) safely allows for incision of the tunica albuginea over the tubing until the point at which the tubing exits the corporal body as it comes off the cylinder. **Routine cycling of the device over time may allow for future exchange to a standard girth cylinder if the patient is dissatisfied with the girth and/or rigidity [18, 19]. This should only be considered after counseling the patient that each revision surgery carries a substantial risk of infection.** If the larger device becomes

infected, the patient returns to square one, making subsequent reimplantation surgery more challenging than before as further corporal fibrosis and scar tissue forms.

46.3.3.4 Graft

Occasionally severely stenotic corpora will not allow for closure of the corporotomy even when using a narrow device. In such cases a graft may be used to close the defect in the tunical tissue. Several different graft materials have been reported including heterologous synthetic (Gore-Tex™ [35, 36], Dacron, Prolene) and biological (human cadaveric fascia, porcine tissue, dermis, pericardium [37–39], and small intestinal submucosa). Autologous grafts can be harvested from various sites including rectus fascia [40], fascia lata, dermis, saphenous vein, temporalis fascia and tunica albuginea [41–43]. While autologous materials offer the advantage of being non-immunogenic and a lower infection risk, they add operative time and morbidity associated with their harvest [38]. Many contemporary prosthetic surgeons prefer the use of pericardium allograft (*Tutoplast*™, Tutogen Medical, Inc., Alachua, FL, USA) or more recently a fibrin sealant patch (Tachosil®, Baxter International Inc., Deerfield, IL, USA). **Our preferred graft is Tachosil® which provides sufficient strength and coverage, but does not require sutures to hold it in place, eliminating the risk of inadvertent puncture of the device with a needle at the time of graft placement [44].**

46.3.4 Reservoir Placement in Scarred Pelvic Areas

Reservoir placement, even in a virgin implant case, can be one of the most challenging steps of IPP surgery, particularly when placing the entire device through a single penoscrotal incision. Placement in this situation is done blindly using the external inguinal ring and pubic tubercle as landmarks, which are not always easy to locate depending on the patient's body habitus and surgical history. Use of excessive force or sharp instruments can result in catastrophic consequences including bladder per-

foration, bowel or vessel injury. In anticipation of difficult reservoir placement (or removal in cases of device exchange), a preoperative assessment should include any history of hernia repair, open or robotic prostatectomy, and localization of defunctionalized reservoirs.

Almost all adult hernia repairs are performed with mesh, which can become densely adherent to the underlying tissues making it difficult to access the external inguinal ring. In patients with a history of hernia repair, this area should be avoided, and attempts should be made to place the reservoir on the contralateral side. This may not be possible in patients who have had bilateral inguinal hernia repair, in which case the surgeon should place the reservoir in an ectopic or abdominal wall position. Methods for ectopic reservoir placement have previously been described and can be accomplished using only the penoscrotal incision, or a variety of different counter incisions. A similar approach should be used in patients who have had an open prostatectomy, in whom it is reasonable to attempt placement in the space of Retzius, as the integrity of the peritoneum is typically preserved. **In patients with a history of robotic prostatectomy, however, the surgery is performed through a trans peritoneal approach, and the space of Retzius may be exposed to intrabdominal contents risking small bowel obstruction, fistula, and erosion.**

Never attempt to inflate a defunctionalized reservoir or instill more fluid than the reservoir originally held, whether it is from a previous revision surgery in which the native reservoir was left in place, or part of a system with a fluid leak. Instilling more fluid can lead to rupture of the capsule around the reservoir, causing collateral injury to surrounding structures including the bladder or iliac vessels [45]. While it is acceptable to leave a reservoir in place during revision surgery done for indications other than infection, (commonly referred to as “drain and retain”), it is preferable to not leave the reservoir or any other components including RTE or tubing sleeves in infected implants as this is a nidus for recurrent infection [46]. In cases where the patient is septic, it may be safer to leave the reservoir retrieval for another day.

46.4 Mechanical Failure

Mechanical failure is the most common indication for revision surgery due to either a leak in the system or a failure in one of the components [2]. Fortunately, revision surgery for a mechanical infection is not associated with the intense corporal fibrosis that characterizes revision surgery after implant removal for infection or priapism. Revision surgery for mechanical failure can be approached in a systematic manner to maximize safety and optimizing efficiency. As mentioned previously in this chapter, preoperative assessment should include knowledge of surgical approach used to implant existing device, cylinder size, use of RTE, as well as the location of the reservoir.

46.4.1 Device Removal

46.4.1.1 Initial Dissection

Accessing the site of the exit tubing for the corporotomy may be easier using the same surgical approach used for initial implantation surgery. This decision is left to the discretion of the prosthetic surgeon, who should use the approach with which he or she is most comfortable. As with a virgin case, insertion of a foley catheter aids in identification of the urethra particularly as the tissue planes and landmarks are not well defined in revision surgery. Dissection should be carried out with electrocautery using #1 pure cutting current ≤ 35 watts, with coagulation current at the same settings rather than with standard instruments like a scalpel or scissors that can transect the device. Using settings higher than 35 watts risks damage to Coloplast components and can make the cylinders more difficult to remove. The pump is typically the easiest component to retrieve, and it is tempting to dissect it out first. **Unfortunately, the capsule formed around the pump can be surprisingly vascular and to go after it initially may mess up the clarity of the procedure by forcing hemostasis of all the neovascularity of the pump's capsule.** If possible, we like to first find the tubing going into the corporotomy and exposing it with the electrosurgical unit follow it until the location of entrance into the corpora is obvious. The tubing is carefully dissected out (exposing the AMS boot) and then the

corporotomy made to remove the cylinders. Then the pump can be exposed by pushing it into the wound and cutting the overlying tissue with the electrosurgical pencil.

46.4.1.2 Retrieval of the Reservoir

Once the pump is freed, the tubing connected to the reservoir should be isolated and traced proximally using electrocautery directly on the tubing. While the pump provides a much larger surface area for cautery, the tubing is narrow and allows little room for error. Blind cutting with electrocautery could result in inadvertent injury to the spermatic cord or bowel contents if a hernia is present. Dissection of the reservoir is best managed with an assistant providing traction of the reservoir caudally, exposing the capsule directly overlying the tubing, while using a baby deaver to retract cranially in the area of the external inguinal ring. An electrosurgical pencil extender, head lamp and/or a lighted retractor can facilitate these maneuvers. **Care should be taken during this dissection to not exert excessive traction caudally as a point of weakness in the tubing can result in inadvertent detachment of the reservoir tubing from the rest of the system.** Depending on how proximal this occurs, it may result in loss of access to the reservoir, in which case it is best to leave the reservoir in place rather than go after it. If this is not an option because the new reservoir needs to be placed on the ipsilateral side, the surgeon may attempt to locate the freed end of the reservoir tubing. If these efforts are unsuccessful, a counter incision will need to be made directly over the external inguinal ring. The surgeon should refrain from using heroic moves to retrieve the reservoir as this can lead to a bladder or vascular injury, and instead should consider abandonment and ectopic placement of the replacement reservoir in these situations.

If one elects to continue with reservoir removal the following steps are recommended. Once the capsule overlying the connection of the pump and reservoir tubing is released, this typically allows for access to a generous length of tubing proximally. With ample tubing exposed, a large clamp is then placed on the proximal end of the tubing and the tubing is transected with scissors. An empty 60 cc syringe with a blunt tip needle is then

inserted into the reservoir tubing and the clamp removed. This accomplishes two objectives, (1) it drains the reservoir facilitating its removal through the external inguinal ring and (2) it confirms how much fluid was in the reservoir. Once the reservoir is deflated, electrocautery is used along the tubing until reaching the reservoir hub, which typically has a circumferential capsule that must be incised at the narrowest point. If despite these maneuvers, the reservoir does not appear to want to come with a firm pull and there are no obvious attachments preventing its release, the urge to just “pull harder” should be avoided in case the reservoir has become attached to the bladder, vasculature, or bowel, in which case ripping it out could have dire consequences. Again, the risks of using heroic maneuvers to remove the reservoir must be weighed against the potential complications of injuring something in the process. **The senior author has had 3 instances of “bleeding I can hear” removing reservoirs. In all instances, he was forced to put pressure on the hemorrhage and call for a vascular surgeon. Nothing is more embarrassing especially if you are the visiting professor and not on your home turf.**

46.4.1.3 Removal of the Cylinders

It is important to differentiate which inflatable cylinder was in place. If it is an AMS device, there is a sleeve of Teflon material on the input tubing placed to prevent cylinder wear at the point where the silicone tubing touches the silicone cylinder wall. **The AMS tubing sleeve notoriously allows tissue ingrowth making it very difficult to remove. For this reason, AMS cylinders are much more arduous and time consuming to extract than Coloplast devices which do not need the boot.** Coloplast tubing is silicone but the cylinder wall is polyurethane. It is particularly important in cases of infection to religiously remove all these “boots” because leaving them behind inevitably results in reinfection. They can be very tricky to identify because tissue ingrowth obscures the fact that they are foreign bodies and in the heat of the surgical battle, mistakes can be made if this point is not foremost in your mind ... **“Remember the boots”.**

Inflation of the cylinder during this dissection assists in differentiating the corpora from the

neighboring urethra. The surgeon should take note of the distal seating in the glans of the old device before it is removed. This allows the surgeon to proceed with confidence that they did not inadvertently cause mischief distally preparing for the new cylinders. Expansion of the cylinder also provides better exposure when making the corporotomy. A similar technique of careful, deliberate electrocautery along the tubing until the point at which the tubing exits the cylinder is used. Due to the acute angle between the cylinder and exit tubing, there is often a bridge of scar tissue tethering the proximal end of the cylinder in place. A blunt tip cautery can be inserted into this crevice to release the final adhesion. The cylinder is then deflated and a right-angle clamp is inserted behind the cylinder in a medial to lateral direction (to avoid urethral injury), thereby removing the distal part of the cylinder.

This is not the time to be minimally invasive when it comes to the size of the corporotomy, because adequate exposure is critical to identifying the edge of the corpora for closure. Stay sutures are then placed with the cylinder still seated proximally to aid in identification of the edge of the corpora. **You would be surprised at how often even experienced surgeons lose the corporotomy because they do not mark the opening with stay sutures.** The proximal base of the cylinder is then removed, and the proximal corpora is inspected to ensure that no RTEs were left behind. **If an RTE has been left behind, a nifty trick to remove it is to fill the proximal corpora with irrigation fluid. Then place an adult Yankaur suction tip into the proximal corpora with suction applied. Chances are that when you remove the sucker, the RTE will be adherent.** If there is any doubt, a nasal speculum and/or flexible cystoscope should be used to inspect the corpora to ensure all components were removed. Upon removal of the cylinders, it is strongly advisable that the cylinders be inspected while inflated with fluid to assess for a source of the leak that led to mechanical failure of the device, and a cylinder aneurysm that may have gone unnoticed during removal of the device as this may require additional measures to reinforce the tunica at that site.

The tunica albuginea is not as easy to identify in a revision case as it is at time of initial

implantation, and there is often overlying scar tissue and dartos fascia obscuring the tunica albuginea making it difficult to differentiate fascial layers. Inadvertent incorporation of this scar tissue or dartos fascia, without actual tunica in the stitch can lead to herniation of the cylinder through the corporotomy. Insertion of a dilator proximally while placing stay sutures will help identify the proximal apex of the corporotomy. The strength and integrity of the tunica in a revision case is often inferior to that of a virgin case, which is why a 2–0 PDS suture is utilized to close the corporotomy rather than a faster dissolving 2–0 Vicryl suture. Even in the absence of prior infection, the surgeon may encounter an area where there is insufficient viable tunica to allow for adequate closure of the corporotomy. In this situation a graft and/or narrow cylinder should be considered. **This highlights the importance of anticipating the unexpected in revision surgery and requires preoperative verification that a graft is available as it may be a special-order item in some hospitals.**

46.4.1.4 Mini Salvage (“Wash Out”) to Prevent Revision Infections

Historic rates of infection with revision surgery were as high as 18%, but with the use of washout irrigation solutions have been reported as low as 2% [9–13]. As stated earlier, the preferred washout solution(s) used amongst expert prosthetic surgeons varies from the classic Mulcahy washout to a single antibiotic solution, or even just irrigation with normal saline. Regardless of the irrigation solution selected, it is strongly advisable that that vigorous lavage be performed.

Some surgeons put on new sterile gowns, gloves, and employ new sterile instrumentation to minimize the risk of subsequent infection. This approach although theoretically reasonable has never been proven scientifically valid. We choose to forego such maneuvers in an attempt to minimize operative time and have had excellent success with revision infection incidence below 2%.

46.4.2 Correcting Impending Cylinder Erosion

Cylinder erosion occurs when the distal tip of the cylinder has advanced through the tunica albuginea and is pressing on skin in the distal penis, into the glans penis, or into the urethra (Fig. 46.11). Impending erosion should be suspected in patients presenting with pain in the distal penis or urethra when the device is inflated. Management of impending erosion in a timely manner is imperative to avoid complete erosion through the tissue exposing the device, which at that point, by definition, is infected.

Impending cylinder erosion shortly following IPP insertion is usually the result of vigorous dilation with small sharp dilators during the initial implantation surgery. Microtears or a small puncture in the tunica may not be evident at the time of surgery, but the cylinders will find the path of least resistance over the succeeding months or even years with sexual activity. Alternative causes of erosion include oversized cylinders, cylinders habitually left in the inflated position, and underlying infection. Failure to recognize an underlying infection will result in

Fig. 46.11 (a) Cylinder erosion through glans. (b) Cylinder erosion through corpora. Removal of entire prosthesis is necessary

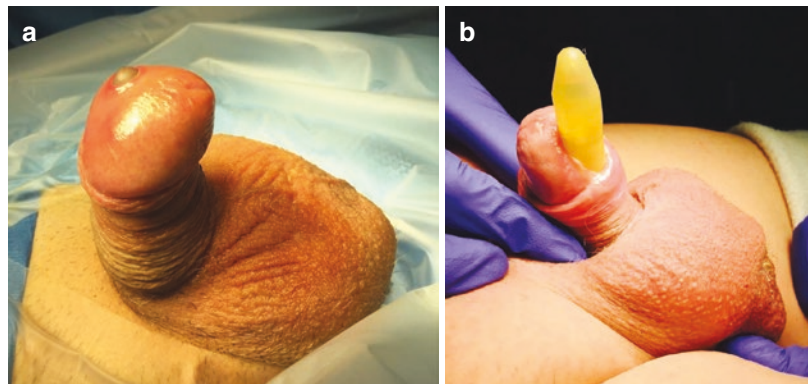
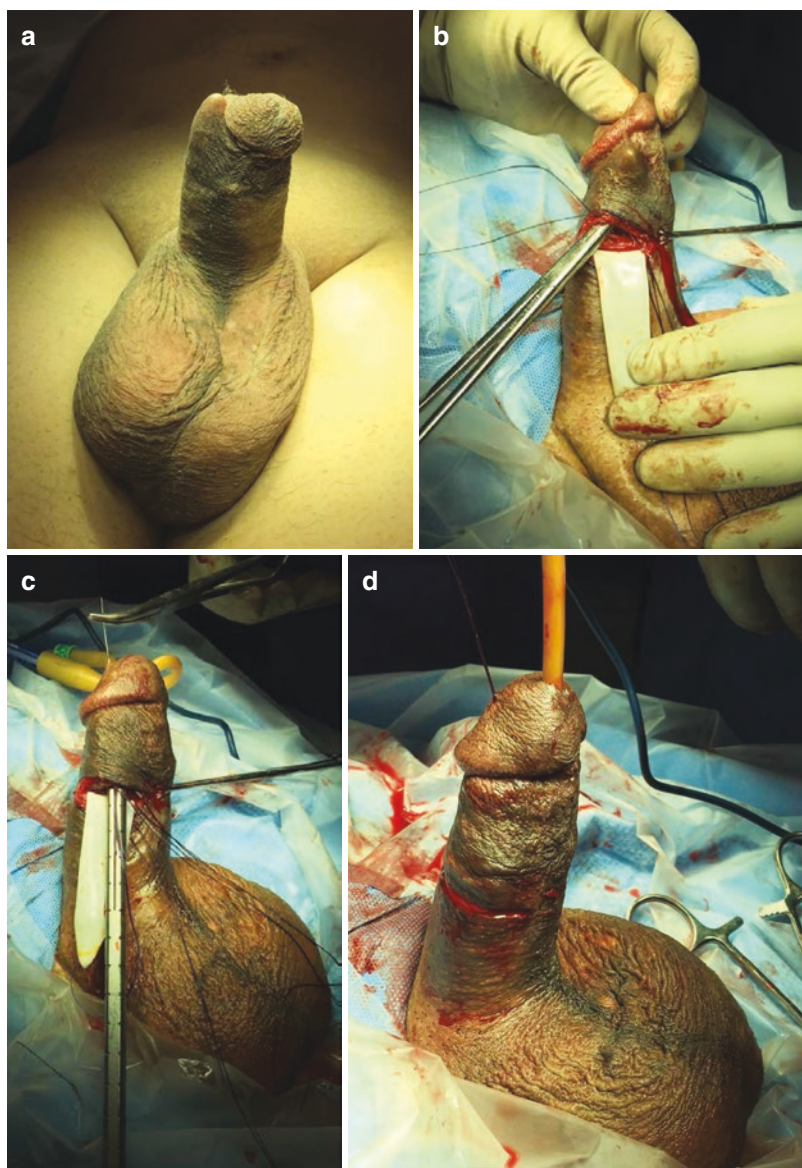


Fig. 46.12 (a) impending cylinder erosion. (b) Demonstration of old cylinder tract. (c) Furlow in newly dilated tract old cylinder rethreaded with guide string. (d) Completed repair of impending cylinder erosion preventing Fig. 46.7



progression of erosion despite any surgical efforts to correct it. An infection is typically associated with erythema, induration of the underlying area, or even drainage through a sinus tract. In the setting of infection, erosion is the body's attempt to extrude an infected device.

Mulcahy devised a simple way to repair impending erosion using the natural tough fibrous capsule that surrounds the cylinders by buttressing the cylinder tip to prevent repeat erosion [47]. Briefly, it is performed by making an incision in the distal penis, and incising the capsule with the device inflated to provide traction. The cylinders

are then deflated so that the cylinder tip can be temporarily removed through the capsular incision. The posterior wall of the capsule is then incised with electrocautery to allow for a new tunnel to be created using scissors and dilators beneath the two layers of capsule. A new guide suture can be constructed by passing a 00 Vicryl through the tip of the cylinder and deploying the cylinder in the new tract using the Furlow insertion tool. The previous tract is then obliterated by incorporating it into the corporotomy thereby buttressing the cylinder to prevent repeat erosion (Fig. 46.12) [45].

In situations where the cylinder is impinging on the glans or urethra, the distal tract of the capsule is closed using a non-absorbable purse string suture in addition to rerouting the cylinder tip. If there is insufficient tissue or if this significantly narrows the corpora preventing adequate closure of the corporotomy, a graft may be used. Biologic materials are preferred to synthetics such as vascular PTFE grafts, Prolene® mesh, or Gortex® due to the risk of infection. While Mulcahy's original repair of impending erosion included leaving the original device components in place, it is reasonable to replace the cylinders with an antibiotic coated sterile device after a mini wash out through a penoscrotal incision to minimize the risk of subsequent revision infection.

46.4.3 Floppy Glans or SST Deformity

Glans hypermobility or SST (supersonic transport or concord) deformity may be seen in cases where the implant is undersized due to inadequate dilation, when a properly sized implant has acted as a tissue expander, or unrecognized proximal corporal perforation has occurred. The resulting deformity is a ventrally tilted glans, and cylinders that end proximal to the coronal margin rather than the mid-glans. It is more commonly seen in uncircumcised patients. It may be recognized at the time of surgery when the device is fully inflated, yet the distal tips do not reach the mid-glans position. Although the device may be properly sized, it may occur because the corporal body itself does not reach mid-glans. The distal

extent of the corpora varies anatomically from one patient to the next, and attempts at aggressive distal dilation may result in inevitable erosion due to weakening of the tunica in this area. If the cylinder is correctly sized, subsequent capsule formation around the cylinder tip may result in a satisfied patient.

In situations where the glans still appears floppy despite adequate healing time, a glans fixation procedure can be performed. The technique was originally described by Ball in 1980 using a hemicircumcising incision just proximal to the glans and dissection carried down to the tunica albuginea [48]. Taking care not to violate the tunica, dissection is carried distally underneath the glans on either side of midline. The cylinder tips will be visualized in the distal corpora under the tunica to allow for deep non-absorbable sutures (i.e. 00 Ethibond on a CT2 needle) from underneath the glans to be placed. The cylinders are then deflated and are milked proximally to avoid injury. Sutures are placed in the distal tunica taking care not to puncture the cylinders. Tying the sutures secures the floppy glans to the distal tunica correcting the problem. While dimples on the glans may be apparent from the underlying sutures, these will recede with time.

A new concept in glans hypermobility is that penile shortening that is known to occur after prostatectomy results in regression of the distal corpora away from the glans. This can result in not only SST deformity but lateral hypermobility or even ventral hypermobility which we refer to as the “howling wolf or baby bird” deformity. Figure 46.13 demonstrates varied glans



Fig. 46.13 Different Glans hypermobility configurations. (a) Classic SST, blue dots denote tips of cylinders. (b) Lateral hypermobility of left cylinder (glans seem-

ingly too narrow). (c) Ventral hypermobility: howling wolf or baby bird

hypermobility states, with the classic SST being the most common experienced.

Our opinion on correction of hypermobility at the time of initial IPP has changed after employing the new technique created by our team [49]. Instead of staging repair and hoping the hypermobility improves or is tolerable to the patient, we fix substantial hypermobility at the time of initial implantation typically adding 20–30 minutes to the case.

Our modified glanulopexy technique avoids inadvertent injury to the neurovascular bundle and simplifies the Ball repair (Fig. 46.14). The current iteration of our procedure begins with

inflating the implant maximally and marking the tip(s) of the offending indwelling IPP cylinder(s) with the glans displaced (Fig. 46.13a, b). The device is deflated and a 1 cm incision is made over the mark(s) and a path is tunneled to the glans (Fig. 46.15a). The proximal dissection is carried to the level of Bucks Fascia and a 2–0 Ethibond® (Ethicon US LLC, Cincinnati, OH, USA) suture is placed with good purchase in the corporal tissue just distal to the deflated device (Fig. 46.15b). Care should be taken to make this bite deep enough to have a solid anchor but avoiding device perforation. The suture is tied, leaving a 5 cm tail to serve as an anchor for sub-

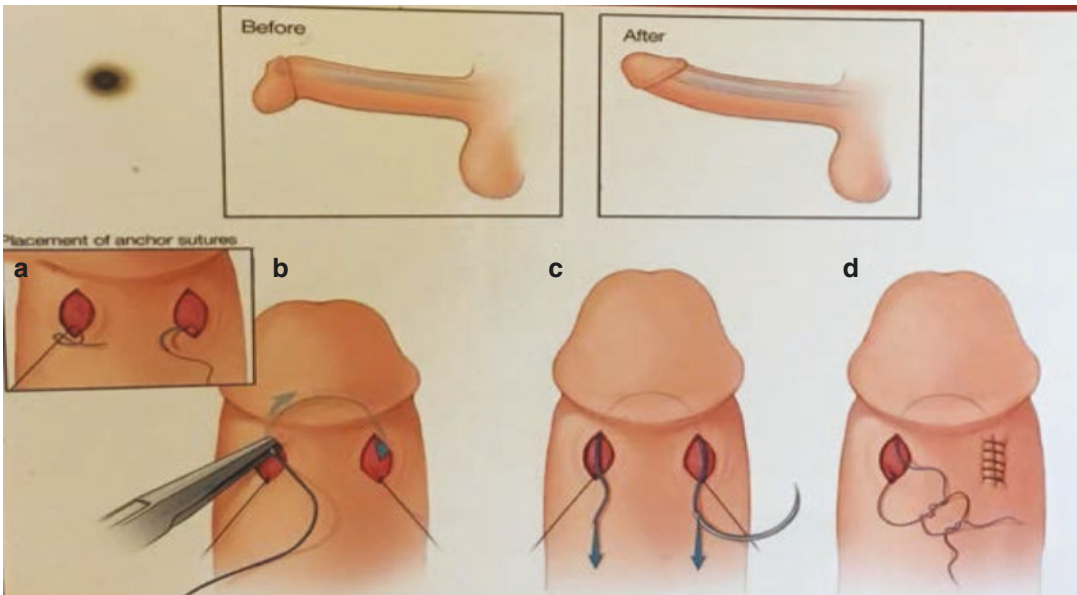


Fig. 46.14 Overview of novel glans fixation technique [47]



Fig. 46.15 Glans hypermobility correction using new technique for classic SST deformity. Correction of photo A from Fig. 46.13. (a) Dissection and tunneling to glans.

(b) Placement 2–0 ethibond sutures: red arrow – fixation sutures, green arrow – glans stitch. (c) End result

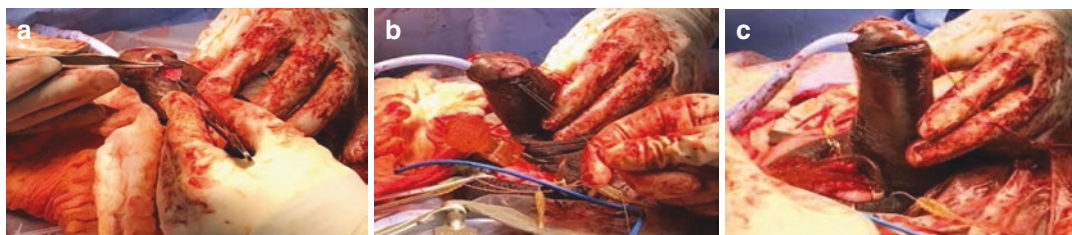


Fig. 46.16 Glans hypermobility correction using new technique for lateral deformity. Correction of photo B from Fig. 46.16. (a) Initial lateral incision (b). Single glans bite on tension (c) End result

sequent tensioning of the glans penis. One can be reassured that the distal device is not susceptible to device puncture as it is solid material. The most crucial part of procedure occurs now when a separate 2–0 Ethibond® on a UR6 needle is used to take a generous bite of undersurface the glans. In a typical SST repair the suture will enter in one opening and the needle retrieved out the other opening (Fig. 46.14b, c). For lateral or ventral laxity the bite can or must enter the same opening respectively to avoid urethral injury in the latter. After all sutures are placed, there should be a glans stitch that can easily manipulate the glans (like reins on a horse) (Fig. 46.15b green arrow) in addition to the previously placed anchor stitch(es) (Fig. 46.15b red arrow). Finally, the glans stitch is fastened to the anchor stitch(es) with the desired level of tension to resolve the glans hypermobility (Fig. 46.15c). Thus far we have experienced no penile loss of sensation or complaints of palpable sutures. The advantage of this approach is that it is faster and avoids the semi-lunar and deep dissection at the corona typically performed in the traditional Ball repair.

46.4.4 Recommended Tools for Complex Revision Surgery

As discussed in this chapter, even for routine revision cases, one should expect the unexpected and be prepared with an arsenal of tools. In addition to the instrumentation needed for a virgin

implant case, additional recommended tools to have available include:

- Uramix dilators and/or
- Carrion-Rossello dilators
- 2 Backward cutting scissors: Heavy Wide and Narrow
- Disposable Scott retractor system with rakes, baby Deavers (AMS SKW Scrotal Retraction System, Coloplast Wilson Scrotal Retractor)
- Biological graft material
- Nasal speculum
- Flexible cystoscope
- Narrow base cylinders
- 2–0 PDS suture
- 2–0 Ethibond suture, CT-2 needle
- #12 blade scalpel
- Electrosurgical Pencil Extender
- Head Lamp or Lighted Retractor
- Blunt Needle tip to easily inflate old cylinders
- Piston Syringe for antibiotic irrigation

Key Summary Points

- Pre-operative preparation prior to complex IPP cases includes a focused physical exam; goals, risks and benefits discussion with the patient, and obtaining previous operative reports that detail previous device characteristics

- Consider obtaining abdominal imaging prior to surgery
- Cases involving corporal fibrosis are difficult. Expect a several hours case and the unexpected.
- No prizes are awarded for small incisions: maximize your exposure
- Spend adequate time dissecting the corpora “squeaky clean” and identify the side walls of the corpora
- Add stay sutures, add second corporotomy, and/or extend corporotomies if encountering difficulty with dilatation
- Place a narrow size device if there is any resistance with 12 Brooks dilator proximally
- Re-inflate old cylinders in situ to facilitate a well located, clean corporotomy and assess for aneurysm and distal seating prior to removal
- Use copious anti-biotic irrigation on device exchange
- Never re-inflate or re-use a defunctionalized reservoir
- Drain and retain is a great approach for difficult reservoir removal in a non-infected setting
- Be aware of modern strategies to fix proximal perforation, cross-over, impending erosion and glans hypermobility
- A counter-incision is never wrong
- Have the necessary advanced implant tools and equipment available

46.5 Conclusion

This chapter has detailed tips and tricks to successfully perform complex penile implant revision. Core principles include pre-surgery planning with appropriate exam and imaging, realistic patient counseling, excellent exposure, knowledge of common pitfalls and tips and tricks

to avoid them, and the use of proper equipment. Remember it is never wrong to rely on the wisdom gained by others’ experiences and ask for help at any time. We hope this chapter lets the reader prevent mistakes and reward realistic patient expectations in this difficult surgery on discouraged patients.

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Prevention of Prosthetic Infection: Penile Implants and Artificial Urinary Sphincters

47

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47.1 Introduction

Infection remains the most feared complication in all prosthetic surgical disciplines. Significant advances have been made to combat this rare but devastating complication over the past several decades, resulting in substantial declines in prosthetic urology infection rates. In this chapter we review prevention and management of infections of penile prostheses (IPP) and artificial urinary sphincters (AUS).

47.2 Historical Perspective

The first inflatable penile prosthesis was introduced in 1973 by Dr. F. Brantley Scott [1, 2]. The original surgical procedure was meticulous. Patients were shaved in the operating room and then underwent a 10-minute povidone-iodine scrub. The operative team was made to scrub in povidone-iodine, and their hands were then sprayed with iodine. They waited for it to completely dry before gowning and gloving. Patients received perioperative antibiotics, but Dr. Scott did not continue them in the post-operative

period. Infectious complications of these early IPPs were low. Device failure and malfunction were more likely to cause complications and re-operations. Dr. Scott performed the surgeries within a closed encasement called a surgical isolation bubble system. In addition to pioneering this chamber (which is no longer used today), he contributed to the invention of the Lone Star Retractor (also known as the Scott Retractor) [1].

47.3 Inflatable Penile Prosthesis Infection

Penile prostheses remain the gold standard for medical-refractory erectile dysfunction with high patient and partner satisfaction rates following successful surgery [3–5]. Over 25,000 penile prosthesis procedures are performed annually in the United States [6]. The procedure is safe and effective but not without risk. Device infection is perhaps the most devastating complication for both surgeons and patients. Infection rates at primary implantation range from 1–3% but can increase to up to 18% at revision surgery [7–10]. Infections are physically and emotionally challenging, expensive, and fraught with potential legal repercussions [6, 11–13]. Significant advances in both surgical technique and device development have resulted in substantial declines in infectious complications over the past several decades [6, 14, 15].

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47.3.1 Types of Infection

IPP infections occur in two general patterns, either immediate or indolent. Immediate infections occur within the first two months after surgery and are thought to constitute the minority of infections. Patients present with physical exam findings including erythema, edema, fluctuance, and drainage (see Figs. 47.1 and 47.2). Some patients present febrile and occasionally septic [16]. Immediate infections are often associated with more virulent organisms including *staphylococcus aureus* and/or enteric Gram-negative bacteria [6, 17].

Indolent infections are more common and lack the classic physical exam findings seen in

immediate infections and may present up to a year after surgery [18]. As a result, indolent infections require a higher index of suspicion on the part of the surgeon. The most common presenting complaint is persistent pain. On physical exam, a fixed in place scrotal pump (see Fig. 47.3) or pinpoint drainage site may be evident [19].



Fig. 47.1 Immediate penile prosthesis infection. Note the visible edema and erythema

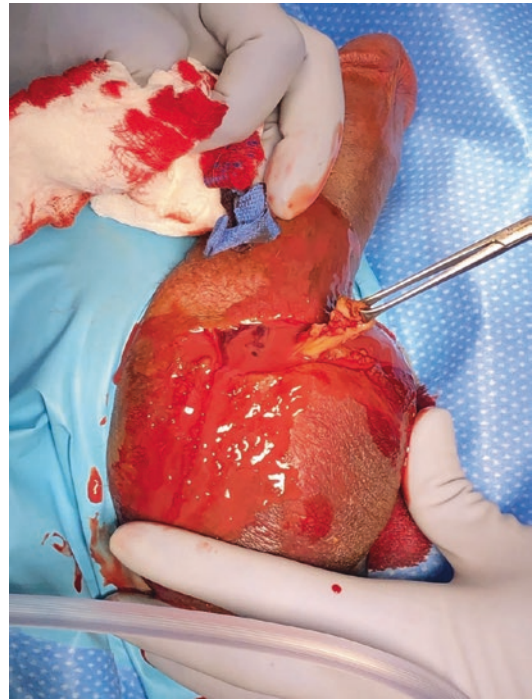


Fig. 47.2 Immediate penile prosthesis infection. Note the purulent fluid. (Image courtesy of Dr. Rafael Carrion)



Fig. 47.3 Indolent penile prosthesis infection. Note the pump fixation to the scrotal wall

Bacteria most often found in culture from these infections include common skin flora [8].

47.3.2 Pathophysiology

The classic teaching is that infection in prosthetic surgery is primarily due to contact with skin flora, although hematogenous spread of infection has also rarely been described [20]. An important concept to clarify is the distinction between infection and colonization. Almost all IPPs will be colonized after placement, whereas an actual infection is much rarer. In a large study of re-operations, Henry et al. found that 70% of prosthesis culture swabs from non-infection-related redo prosthetic procedures were positive for bacteria. *Staphylococcus epidermidis*, a skin bacteria of low virulence, was the most commonly isolated bacteria in that series [21]. Bacteria are thought to persist on the implant surface through a protective biofilm.

Biofilm is an important aspect in the pathophysiology of infections [8, 22, 23]. Biofilm is a slimy matrix of extracellular polymeric substances secreted by bacteria once they have anchored on to the device. Four steps have been described in biofilm formation:

1. Attachment
2. Accumulation of extracellular polymeric substances
3. Maturation
4. Detachment [24].

When the bacteria are detached during IPP revision they can migrate and create new biofilm or cause infection elsewhere. Biofilm acts as a barrier to protect the bacteria from host immune response and antibiotics while simultaneously providing nourishment. The increased prevalence of infections at IPP revision surgeries is due to biofilm disruption and persistent bacterial presence [23].

47.3.3 Risk Factors

Certain medical comorbidities place patients at higher risk for IPP infections during primary

placement. While the exact relationship between diabetes and infectious risk in IPP placement is still undefined, higher glucose levels theoretically favor bacterial growth and reproduction. Many studies have examined this relationship with mixed results, but the majority of research suggests that poorly controlled diabetics are at increased risk of infection [4, 6, 25–30]. Varied results also exist regarding spinal cord injury patients. The majority of studies show higher rates of infection, while one showed no difference [27, 31–33]. Definitive relationships between infection and implants in other distinct medical populations is yet to be determined. Sidi et al. followed penile implants in 14 renal transplant patients and concluded that this population was not at increased risk of infection [34]. However, when examining long term immunosuppression, Wilson et al. found that this was significantly associated with increased infection rates [27]. Along these lines, HIV positivity is associated with increased infectious rates, perhaps related to CD4 count [27, 33, 35].

Other inherent patient risk factors relate to patient lifestyle choices. Balen et al. examined socioeconomic and health risk factors for infection over a 12-year period. They concluded that active polysubstance abuse, homeless status, and poor preoperative glycemic control were all associated with increased infection at primary implantation [33].

During repeat procedures, prolonged operative time, scar tissue, and decreased blood flow all contribute to higher infection rates [6]. Modifiable inherent patient risk factors at primary device implantation and at revision surgery are highlighted in Table 47.1. It is important to note the differences in risk factors depending on primary vs revision surgery.

47.4 Inflatable Penile Prosthesis Infection Prevention

Substantial effort and research has been devoted to reducing IPP infection rates in the last four decades. There are a number of evidence-based infection prevention techniques that are widely utilized, as well as other options that are not

Table 47.1 Modifiable risk factors at primary and revision IPP surgery

<i>Modifiable risk factors at primary surgery and proposed intervention</i>	
Blood Glucose >200 [4, 6, 25–30, 33]	Medically manage intra-operatively
Spinal cord Injury [27, 31–33]	Careful patient selection; thorough counseling
HIV Positivity [27, 33]	Careful patient selection; thorough counseling
Immunosuppression [27]	Modify as able
Polysubstance Abuse [33]	Pre-operative therapy and drug cessation
<i>Modifiable risk factors at revision surgery and proposed intervention</i>	
Diabetes Mellitus [4, 6, 25–30, 33]	Medical optimization; intra-operative glucose control; anti-fungal prophylaxis
Prior implant Surgery [61]	Careful patient selection; thorough counseling
Biofilm [61]	Peri-operative antibiotic selection; wound irrigation and washout

evidence-based but are widely implemented and anecdotally successful. Infection prevention begins well before surgery and continues throughout the perioperative period, as detailed below.

47.4.1 Preoperative Steps

Infection prevention starts during the preoperative evaluation in the clinic. A thorough history and physical exam is essential, especially paying close attention to the infectious risk factors discussed earlier. Modifiable health issues, like glucose control and use of antiretroviral therapy, should be addressed before surgery. The patient's groin should be evaluated for bacterial or fungal skin infection, as this must be treated with oral medication before surgery. Preoperative urine cultures are commonly performed and should be treated if positive. More recently, their role in the preoperative evaluation is being questioned, but they remain a standard preoperative lab test [36, 37]. A Hemoglobin A1c may be obtained but, as mentioned earlier, the exact role of long-term preoperative glucose control in infections is

unclear. One study reported higher rates of infection in diabetics with a HbA1c higher than 11.5% at the time of surgery [30]. Other authors have suggested that HbA1c of 8.5% is predictive of infection, although the studied population predominantly consisted of patients with malleable penile prostheses [38].

Preoperative diagnosis of staphylococcus aureus colonization, followed by appropriate treatment, has been associated with 20% lower rates of surgical site infections in other surgical disciplines. We use *s. aureus* nasal swab testing and pretreat positive patients with nasal mupirocin. All patients are ordered to scrub with chlorhexidine while bathing once a day for a week prior to surgery [39]. Historically this practice has been shown to be beneficial in other surgical disciplines, although more recent reviews of the data have been mixed regarding a significant benefit [40].

A final physical exam in the preoperative holding area is imperative, and any worrisome findings such as open sores, fungal infections, or rashes, must result in delay of the procedure. Preoperative glucose should be checked in the preoperative holding area, and values that increase risk of IPP infection should delay surgery. An insulin drip may be utilized for certain patients, but surgical delay until proper glucose control is achieved is preferred [33].

Preoperative hair removal remains a question. This is routinely performed for surgical exposure and to decrease any potential risk of infection from the hair. Overall, data suggests no difference in infection rates for hair removal the day prior to surgery when compared to the day of surgery. This was best analyzed in a Cochrane review that demonstrated multiple findings [41]. First, any hair removal vs no hair removal had no impact on incidence of surgical site infections. Next, when hair is removed, clippers have lower rates of infection vs shaving and this is thought to be due to less skin trauma and bacterial seeding [42]. No trials have examined cream hair removal vs clipping but when comparing creams to shaving, no surgical site infection difference was found. Hair clipping one day prior to vs the day of surgery similarly

has no effect on infection rates. Based on the above data, the Sexual Medicine Society of North America (SMSNA) recommends either clippers or razors for hair removal prior to prosthetic surgery [43].

The American Urological Association and the European Association of Urology have recommended guidelines for preoperative antibiotic intravenous prophylaxis [44]. Recent research has questioned the utility of these guidelines in covering the most common infectious organisms seen during salvage or explant [45]. Antibiotics should be instilled within two hours of surgery and can be safely continued for 24 hours [46]. Many prosthetic urologists continue oral antibiotics postoperatively however there are no data to recommend this practice.

47.4.2 Intraoperative Steps

Significant variation exists among urologic prosthetic surgeons in hand scrub technique. A randomized control trial compared traditional preoperative scrubbing with an aqueous alcohol-based hand rub in reducing rates of infection in a variety of cases from a range of surgical fields. The study found that not only was there no difference in surgical site infection rates between the two groups but also that the hand rub group demonstrated higher compliance rates [47]. In addition to the type of surgical scrub, the duration has also been examined. The Centers for Disease Control and Prevention (CDC) recommend a 2–6 minute hand scrub prior to any surgical procedure but shorter times have also been studied to be equally effective [48]. No studies specifically examine these questions in the prosthetic urology literature. Gowning and gloving follows hand washing. A Cochrane review found no difference in surgical site infections based on wearing one or multiple pairs of gloves [49]. We recommended double gloving in case a break in a single glove introduces bacteria into the surgical site.

In addition to an appropriate sterile preparation, the surgical team is vitally important. We recommended a consistent operative team with minimal transitions and no extraneous traffic through the

operating room. The anesthesia team also plays a role in reducing infection by maintaining body temperature and oxygenation [50, 51].

The patient's skin should be prepped with chlorhexidine-alcohol (or another alcohol containing solution), as recommended by the North American Consensus Document on Infection of Penile Prostheses [52]. Two major studies contributed to this recommendation and are described below. The first study, by Yeung et al., examined efficacy of chlorhexidine-alcohol vs. povidone-iodine skin preparation in their ability to sterilize skin in urologic prosthetic surgery. They found a 50% lower post-preparation positive culture in the chlorhexidine group. Furthermore, the chlorhexidine preparation more effectively sterilized against coagulase negative staphylococcus [53]. In 2010, a study by Darouiche et al. examined surgical-site infections of clean-contaminated surgery using either chlorhexidine-alcohol or povidone-iodine skin preparation in over 800 patients. The group found an almost 50% decrease in surgical site infections when using the chlorhexidine-alcohol solution (9.5% vs 16.1%, $p = 0.004$). The benefit was observed in both superficial and deep infections [54].

IPP infection rates were substantially reduced in the early 2000s when both Coloplast (Minnetonka, Minnesota) and AMS (Marlborough, Massachusetts) released infection retardant coatings (IRCs). AMS (now Boston Scientific) devices use InhibiZone®, a proprietary blend of rifampin and gentamicin that is placed on the devices during manufacture. Coloplast devices have a hydrophilic coating that allows for surgeon selection of appropriate antibiotic solutions. When compared to their non-coated counterparts, these device changes have resulted in a 50–70% reduction in infectious complications [55].

As the most common bacterial offenders in prosthetic infections are skin flora, the no-touch technique (NTT) was pioneered by Eid in 2011 to minimize skin contact [56]. This surgical approach includes covering the entire surgical field with an adherent sterile drape such as the Steri-Drape® or Ioban® (3 M, Maplewood, Minnesota) and making the skin incision through

this drape. The surgical team undergoes multiple glove changes throughout the case as new gloves are required after any contact with skin or with a change in instruments. A retrospective analysis of the no-touch technique revealed a 77% decrease in infection rates in IRC coated devices when using the NTT [57].

There are a variety of surgical approaches for the implantation of a penile prosthesis, including subcoronal, infrapubic, and peno-scrotal, and there does not appear to be any association between approach and surgical site infections. A large retrospective review by Garber et al. looked at over 300 patients stratified based on penoscrotal vs infrapubic approach and found no difference in infection rates [58].

Many studies across all fields suggest that centers with high surgical volumes have fewer complications and exhibit shorter operative times [59]. As increasing operative time is associated with IPP infection, the procedure should be kept as brief as possible [60]. Conducting other procedures at the time of IPP implantation is not recommended as this contributes to longer operative times and potentially to higher infectious rates.

47.4.3 Postoperative Steps

Steps to reduce post-operative hematoma include the application of a constricting surgical bandage. This Mummy wrap bandage technique was described by Henry in 2009 and a retrospective analysis demonstrated an over 80% decrease in infection rates, attributed to decrease in hematoma formation [33, 61]. In addition to the appropriate surgical dressing, tight closure of corporotomy sites, device inflation, and surgical drain placement have been associated with decreased hematoma formation. A multicenter study examining hematoma and infection rates with drain placement revealed no increase in infection and an overall low rate of hematoma formation [62]. Many experienced surgeons use a 7 mm Jackson-Pratt® (Cardinal Health, Ohio) drain for 12–24 hours post-operatively.

47.4.4 Revision Surgery Steps

In 2005, Henry et al. published a study of aggressive surgical site washout at the time of revision surgery [63]. This has been, arguably, the single most important factor in reducing infectious complications at revision procedures. In their multicenter retrospective study, a 75% decrease in infectious complications was noted for patients who received an antiseptic irrigation during revision surgery compared to those who did not. Another study conducted with saline irrigation found similar results [57]. Based on these studies, with similar data and different irrigation techniques, it is likely the process of vigorous irrigation that leads to decreased infections and not necessarily the type of irrigation.

47.5 Inflatable Penile Prosthesis Infection Treatment

47.5.1 Nonoperative

Some urologists have attempted to treat early infections with conservative management. One study treated 37 men with early signs of local penile prosthesis infection with oral antibiotics only. Approximately 80% of these patients avoided surgery. The inclusion criteria for this study were very strict, however, and included a WBC <13 k and no temperatures >37.5 °C [64]. These findings have not been duplicated in larger studies. We feel very strongly that patient selection for conservative management must be highly selective and adequate guidelines do not currently exist.

47.5.2 Operative

Once the diagnosis of IPP infection is made, the next step is surgical salvage or explant. Infection management was transformed in 1996 with the introduction of three-piece IPP salvage by Mulcahy. In this technique, the infected device is removed, a thorough washout is performed, and a

new three-piece IPP is placed. Data have shown an 82% infection-free rate as well as decreased penile inactivity, fibrosis, and length loss when compared to delayed re-implantation [65]. This technique was updated in 2016 with the introduction of the Malleable Implant Salvage Technique, where a malleable implant is placed instead of an inflatable device, which results in a 93% infection-free rate. Salvage is the gold standard in IPP infection treatment for appropriate patients, however it is likely underutilized [66].

A recent multicenter analysis of IPP infections proposed the following algorithm for treatment:

1. Aspirate/swab the device for culture
2. Administer broad-spectrum antibiotics and antifungals to cover Gram-positive, Gram-negative and anaerobic bacteria as well as fungi
 - (a) Specifically recommended: vancomycin, piperacillin-tazobactam, and fluconazole
3. Perform explant or salvage procedure
 - (a) Malleable implantation is preferred due to the higher infection-free rate
 - (b) Antibiotic immersion for a hydrophilically coated device should also be broad spectrum, with vancomycin and piperacillin-tazobactam. If a Coloplast device with a hydrophilic coating is used, then it may be appropriate to add amphotericin to the dip solution for antifungal prophylaxis.
 - (c) Explantation without reimplantation is recommended for complex patients with sepsis, erosion, necrosis, unstable clinical picture, etc.
4. Follow cultures, tailor antibiotics as indicated [45].

47.6 Conclusions

IPP infections have declined in the modern era due to IRCs, precise operative techniques, and improved patient selection. When infections present, they are devastating and can pose serious clinical challenges. Recognizing and immediately treating IPP infection is imperative.

47.7 Artificial Urinary Sphincter Infections

First described in 1973, the artificial urinary sphincter (AUS) is the gold standard for male stress urinary incontinence and offers excellent surgical outcomes and patient satisfaction [67]. The majority of infectious complications in prosthetic surgery are attributed to IPPs, as IPP insertion volume is significantly higher than AUS insertion volume. In a nationwide study of all Urologic prosthetic readmissions over a one-year period, only 25% were attributed to AUS placement [68]. AUS infections rates, however, are slightly higher than IPP infection rates, ranging from 1–6%.

The literature regarding AUS infection is far less robust than for IPP infection [69–74]. Aside from articles reporting rates of AUS infection, few series describe the authors' experience with managing this complication. Most papers group AUS infection with AUS erosion, which makes exact rates of infection impossible to determine. One series of over 900 patients correlated AUS complications with reasons for incontinence and found that history of cryotherapy, myocardial ischemic attack, and increasing patient age were associated with increased odds of infection. No association with prior pelvic radiation was found [75].

47.8 Artificial Urinary Sphincter Infection Prevention

The AUA Guidelines recommend the same preoperative intravenous antibiotic coverage for sphincters as they do for penile prosthetics. And while many surgeons continue antibiotics postoperatively, this also has not been established as beneficial. Kavoussi et al. also found no difference in AUS infections with or without preoperative urine cultures [36].

In 2008, AMS began applying the InhibiZone® antibiotic coating to the cuff and pump portions of the AUS along with the tubing connecting these segments. One study comparing infection rates with between IRC and non-coated sphincter in over 400 patients found no difference [76].

47.8.1 Revision Surgery

Rates of AUS revision surgery vary in the literature and are quoted from 20–50% [77–80]. In the largest series of AUS follow-up to date, Linder et al. describe a device revision rate due to infection and/or erosion of 10% of over 700 patients [81]. This is similar to AUS revision rates for infection seen in smaller studies [82]. Other studies report rates of repeat infection/erosion after revision surgery ranging from 8% to 35% [81].

- The most common infectious pathogens are common skin flora, however virulent gram negative, anaerobic and fungal organisms are increasingly seen and should be covered with appropriate agents at revision or salvage surgery.
- Numerous surgical techniques can and should be implemented for penile prosthesis infection prevention.
- Infections are less common in artificial urinary sphincters when compared to penile prostheses.

47.9 Artificial Urinary Sphincter Infection Treatment

In contrast to IPP infections, AUS infections require immediate explantation with delayed replacement. Serag et al. describe managing infections with antibiotics and delayed device removal or, if the infection is a superficial skin infection, only treating with oral antibiotics [82]. No literature similar to the salvage procedures outlined for IPPs as above exists.

47.10 Conclusions

The majority of infection prevention research applies to IPPs. It stands to reason that similar approaches would prevent AUS infection. Most of the AUS literature focuses on efficacy and erosion. The AUS infection literature is underexplored and offers opportunities for further research into prevention and management strategies.

Key Summary Points

- Modifiable risk factors for primary penile prosthetic surgery include poly-substance abuse, HIV positivity, immunosuppression, blood glucose >200 mg/dL, and history of spinal cord injury.
- Modifiable risk factors for revision prosthetic surgery include biofilm, diabetes, and the prior prosthetic surgery.

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Management of Non-infectious complications during and after Inflatable Penile Prosthesis Placement

48

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48.1 Introduction

Penile prosthesis implantation has been proven to be an effective management approach for medically refractory erectile dysfunction (ED). The inflatable penile prosthesis (IPP) is among the most reliable medical devices currently in use with over a 95% 5-years survival, 80% 10-years survival and over 70% 15-years survival [1]. In the hands of an experienced surgeon, the surgery offers a high patient satisfaction rate and a low rate of complications. This relationship between patient outcomes and surgical volume has been well documented for IPP placement [2]. Given that most urologists who perform fewer than five implants per year are responsible for more than 75% of penile prosthesis placement in the United States and United Kingdom [3, 4], awareness of intraoperative and postoperative obstacles is pivotal. Moreover, every sur-

geon should be prepared and know how to troubleshoot these complications.

The goal of this chapter is to present the most common non-infectious complications during and after IPP surgery and provide ways to avoid and work through these problems in order to increase patient satisfaction. The prevention and management of infection after IPP placement will not be discussed in this review.

48.2 Intraoperative Complications

The best approach to complications during surgery is always prevention. Careful preparation prior to surgery and understanding all possible issues that may arise is crucial.

48.2.1 Corporal Dilation

Penoscrotal and infrapubic approaches are highly effective for smooth implantation. Ultimately, the decision for which approach to use is left to the discretion of the surgeon and is often dictated by familiarity and previous training. Regardless of the surgical approach chosen to place the implant, adequate exposure of the corpora is paramount. The corpora cavernosa should be accessible and visible without any overlying tissues, and the corporotomies should be properly sized.

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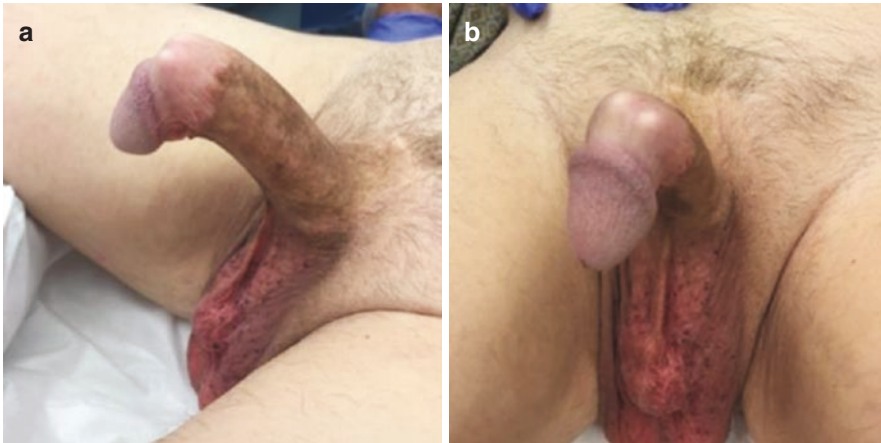


Fig. 48.1 Flail penis as a result of difficult dilation during penile prosthesis implantation. (Dr. R Carrion, USF Health)

A corporotomy that is too small can cause difficulty during dilation and placement of the cylinder base, while larger corporotomies can cause an incompletely closed corporotomy. This can increase the risk for bleeding/hematoma formation and cause an unintended damage to the cylinder while trying to reinforce the closure. Dilation is usually done with the use of Hegar or Brooks dilators. Hegar dilators have the disadvantage that the entire length of the instrument is the same diameter which may create higher resistance, while Brooks dilators have a bullet configuration on the end that creates less resistance. The steel stem of the Brooks dilator is also in a “Z” configuration which can make the dilation passes easier. During distal dilation, dilators should always be angled dorsolaterally to avoid urethral injury and proximal dilation should be performed taking into consideration the lateral route of the proximal crura.

It is helpful to consider the minimal diameter required for the cylinders available during implantation. Boston Scientific’s AMS (American Medical Systems) 700 CXR and Coloplast Narrow Base cylinders only require dilation to 9 mm. AMS CX and LGX require dilation of 11 mm, while Coloplast’s Titan cylinders require dilation to 11 or 12 mm proximally and 9–10 mm distally. While most prosthetic surgeons perform corporal serial dilations for virgin IPP cases, Moncada et al. suggested that dilation is not necessary during IPP placement. One hundred patients were randomized to penile implantation

with vs without prior dilation of the corpora cavernosa. The patients who did not undergo dilation underwent IPP placement with the Furlow device (9 mm diameter) which was only used for measurement and placement of the cylinders. Although the clinical significance of their findings is questionable, the study showed no difference in complication rates, but a statistically significant increase in flaccid penile length along with decreased OR time and postoperative pain in the non-dilated group [5]. Despite which surgical technique is undertaken it is imperative to ensure proper cylinder placement to avoid patient dissatisfaction (Fig. 48.1).

48.2.2 Corporal Crossover

Dilation of the corpora during IPP placement has been reported as a challenging step for the delayed occurrence of complications [8]. When two cylinders end up within the same corporal body either proximally or distally, one has crossed over the midline. The septum of the corporal bodies is fenestrated and lends itself to violation during instrumentation. The best approach to prevent crossover is to always keep in mind the dorsolateral angle during corporal dilation. Indicators for corporal crossover include contact during simultaneous dilation, unequal corporal measurements, difficulty with placement of the second cylinder, misalignment of the urethral catheter off midline between the two inflated cylinders, and a lop-

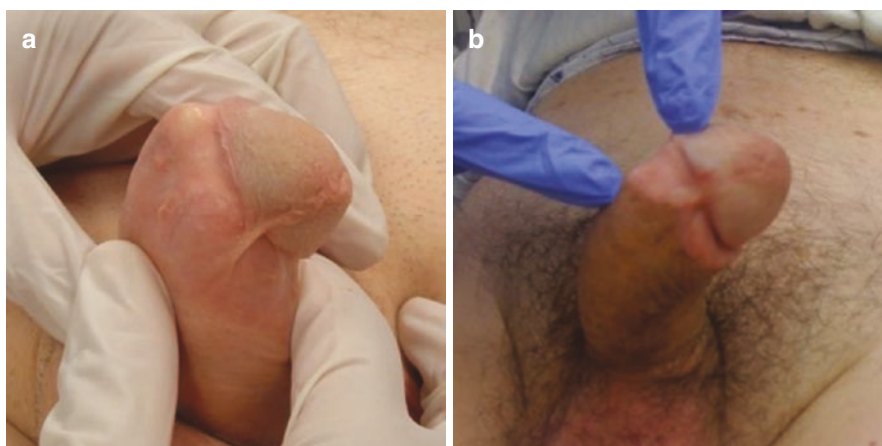


Fig. 48.2 (a) Distal crossover with lateral droop of the glans. (b) Distal crossover with de novo penile angulation. (Dr. R Carrion, USF Health)

sided, unusual erection upon cylinder inflation [6, 7]. Cylinder crossover will result in penile deformity or shortening and the development of a fibrous capsule around the implant that will require additional surgical intervention to correct. It is important to be able to identify and correct this at the time of surgery to avoid having the patient complain during his postoperative visit of de novo angulation or persistent pain in the penis upon inflation of the cylinders.

Distal crossover probably occurs more frequently in infrapubic placement of cylinders. If the penis is not on stretch, and the surgeon is not careful, it is quite easy to pass the Furlow needle-introducer device over the opposite side and back to the same side before firing the needle through the glans penis. Distal cylinder crossover can be very subtle at the time of surgery but can be obvious after a few months. (Fig. 48.2) In the intraoperative setting, this is usually easily remedied. Remove both cylinders, place a dilator in the common cavity that receives the crossover, redilate the opposite cavity being sure to dilate laterally with the tip indenting the skin outward. Next, pass the Furlow needle-introducer device, and while maintaining the dilator in the “crossover” side, the first cylinder is placed. Finally, you remove the dilator and pass the Furlow on the side originally holding both cylinders and place the second cylinder [6].

Proximal corporal crossover is caused by corporal fibrosis and technical errors. A proximal

crossover is suspected when the first cylinder base has passed through the septum, occupies the contralateral corpora, and the surgeon has difficulty placing the base of the second cylinder. This technical error can occur when the surgeon does not respect the natural lateral divergence of the proximal crura during dilation. Similar to distal crossover, proximal corporal crossovers are managed by placing a dilator in the normally dilated corporal side. A second dilator is then passed proximally into the contralateral corpora and a clinking metal sound confirms the crossover. If this happens, the surgeon should reposition the dilator laterally to create a more lateral plane. When the handles of the dilators look like an American football field goal post, successful correction of the crossover has ensued [9] (Fig. 48.3).

48.2.3 Proximal or Crural Perforation

Another well-known intraoperative complication is tunical perforation-injury during proximal dilation. This usually occurs in patients with corporal fibrosis. When the corporal body is scarred, there is a tendency to dilate forcefully downward which may lead to perforation. Like corporal crossover, if proximal perforations go unrecognized, problems may arise postoperatively. The cylinder will eventually migrate through the perforated window and the distal end of the cylinder will be felt in the midshaft. (Fig. 48.4) One way to prevent

this complication is by avoiding the use of narrow (<9 mm) caliber dilators [10]. Traditionally, a perineal incision was made to repair the defect.

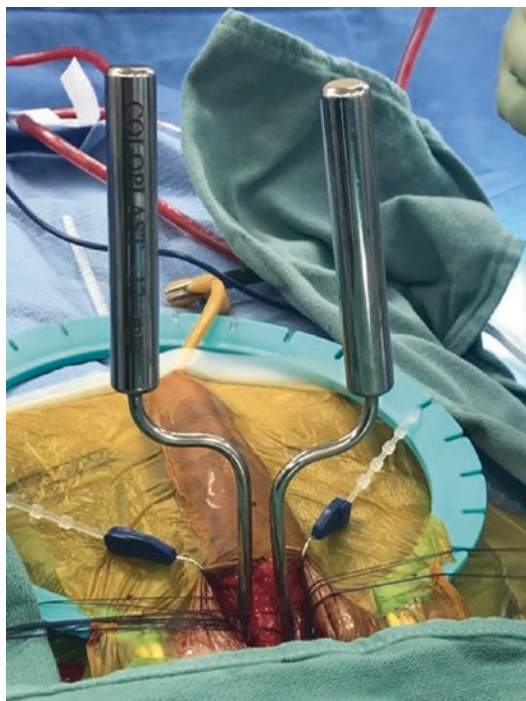


Fig. 48.3 Brooks dilators placed within each proximal corpora. Dilators are at the same length and resemble an American Football field goal post, demonstrating correction of proximal crossover. (Dr. R. Wang, UT/MDA)

Repair involved repositioning the patient into the lithotomy position, and a complicated closure or a graft ‘windsock’ placed around the base of the cylinder which was fixed to the adjacent corporal tissue. However, due to its complexity and high rate of postoperative infection when synthetic graft material is used, direct closure of the perforation is not advised [11, 12].

In order to avoid closure of the defect, experts have adopted methods to keep the cylinder base from migrating down through the defect and allow the perforation to scar over the base of the cylinder. Wilson described the use of the rear tip extender (RTE) sling that addressed the perforation without the use of graft material [13]. First, the non-perforated side is measured and will determine the total length of the cylinder and rear tip extender of the affected side. A non-absorbable suture (00 Prolene) is placed through the lateral tunica albuginea wall at the level of the corporotomy, passed through the proximal end of the RTE, and then passed through the medial corporotomy wall. (Fig. 48.5a) Cylinders are then implanted in standard fashion and the corporotomies are closed. The guide sutures exiting the glans are held on tension to ensure the RTE is not extending through the perforation tunnel. With the prosthesis fully inflated, the suture sling is tied and acts as a hammock, keeping the cylinder

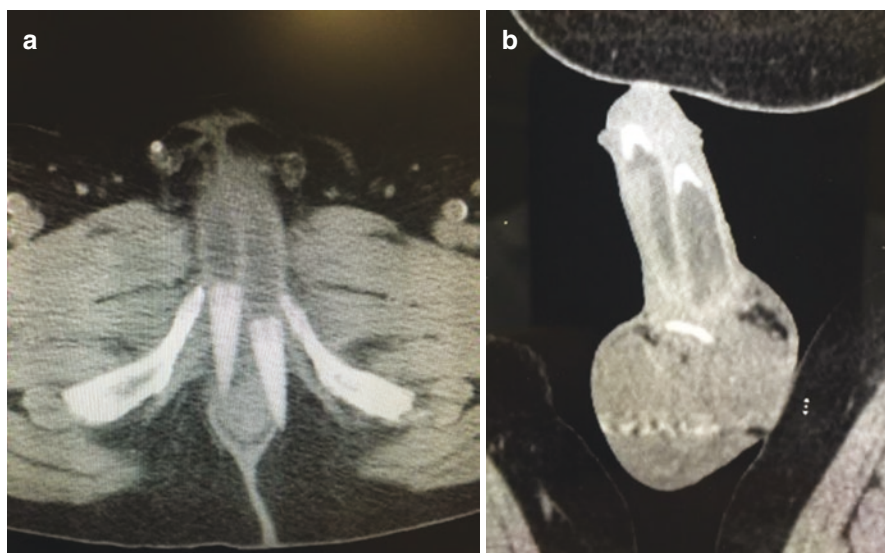


Fig. 48.4 Proximal perforation (a) Left proximal perforation. Patient complained of pain while sitting down. RTE was palpable on digital rectal exam. (b) Migration of left cylinder with tip at the mid shaft. (Dr. R Carrion, USF Health)

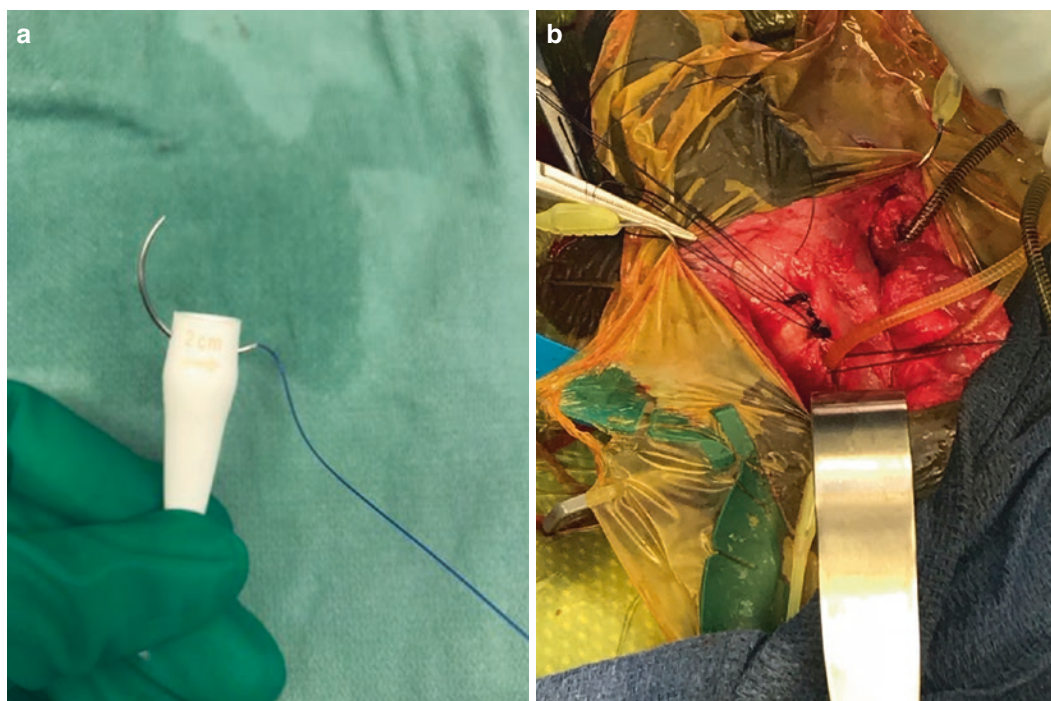


Fig. 48.5 (a) RTE sling which serves as a hammock to keep the proximal edge of the cylinder from migrating through the perforation. (b) While the cylinder is being

pulled by the string exiting the glans, the corporotomy stay sutures are tied around or below the tubing exiting the cylinder in the perforated side to avoid proximal migration

base from sliding proximally. After surgery, the development of fibrous scar tissue will encase and fix the cylinder into place. Another maneuver used to prevent proximal migration is to fixate the input tubing with the stay sutures at the level of the corporotomy. (Fig. 48.5b) In order to allow time for the fibrous capsule to form, patients are advised to avoid sexual intercourse for at least 6 weeks postoperatively [11].

48.2.4 Distal Perforation

Distal perforation may occur during dilation of the corporal body or during penile modeling to correct Peyronie's disease [11]. This can be avoided by isolating the urethra by firmly squeezing the glans immediately proximal to the glans during dilation in an infrapubic approach and during manual modeling for Peyronie's disease [14]. Indicators of distal perforation include seeing blood, dilator or the tip of the cylinder at the urethral meatus. (Fig. 48.6) Confirmation of urethral perforation is usually obtained by noticing a

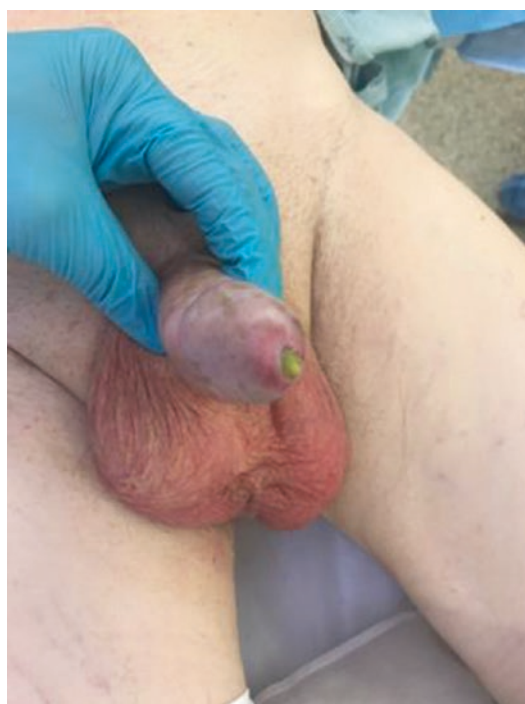


Fig. 48.6 Urethral perforation. Distal tip of cylinder is visualized within the urethral meatus. (Dr. R. Wang, UT/MDA)

rush of fluid from the meatus after injecting irrigation fluid into the corporotomy. The safest course is to abort the surgery, address the urethral injury, and consider IPP re-implantation 2 or 3 months later. If the penile prosthesis is implanted, leaving cylinders adjacent to an unrepaired urethral injury increases the risk of implant infection and impaired wound healing.

A distal urethral injury should be evaluated and assessed for the need for primary closure. Small distal urethral injuries may heal without repair. Prolonged catheter placement is usually not necessary given that the urinary stream will draw tissue fluid into itself from the perforation rather than allow urine to infiltrate the corporal cavity [7]. However, larger injuries typically require repair and an adequate exposure for a 2-layer closure. A single cylinder may be placed in cases of unilateral urethral injuries that are adequately repaired [6]. However, one must take into consideration that patient satisfaction with a single inflatable cylinder is considerably lower than with two cylinders [6].

More recently, some surgeons have adopted ways to avoid aborting prosthesis implantation after distal urethral injuries. Anele et al. [15] published a series of 4 urethral injuries out of 243 patients who underwent primary urethral repair and temporary suprapubic cystostomy allowing for successful completion of unaborted IPP implantation. Urinary diversion with suprapubic tube (SPT) was maintained for 4–8 weeks to allow for urethral healing. After 6 months follow-up, there were no reports of infection, erosion or mechanical failure. Another option that is rarely utilized for distal urethral/meatal injuries is to create an iatrogenic hypospadias in order to access the urethral perforation. Once a two-layer closure of the urethral perforation is performed, the IPP cylinders are implanted and a 14-Fr foley catheter is left in place for 3–5 days. The goal is that the hypospadiac meatus minimizes the pressure differential between the urethral catheter and the corporal cylinder by allowing the urine to exit proximal to the injury. The author of this technique recommends to avoid prosthesis cycling and sexual intercourse for 6 weeks to avoid re-perforation [16].

48.2.5 Intraoperative Reservoir-related Injuries

When placing an IPP through a penoscrotal approach, reservoir placement is performed blindly, which can be stressful for some surgeons. The goals to favorable reservoir placement include preventing the patient from feeling or seeing the reservoir, preventing autoinflation, and limiting any other more serious complications such as injury to bladder, bowel or vessels. It is important to note that reservoir-related complications are relatively rare in the hands of an experienced surgeon. However, a complication during placement of a reservoir can make a relatively easy operation become a disaster. Penile prosthesis reservoirs have been traditionally placed in the prevesical space, or Space of Retzius (SOR), below the abdominal wall fascia. Levine and Hoeh presented their technique of traditional reservoir placement in the SOR to avoid creating inguinal floor weakness and visceral injury [17]. In their technique, Jorgensen scissors are used to pass through the penoscrotal incision, inguinal ring and over the pubis with the tips pointing posteriorly to perforate the transversalis fascia and gain access to the retropubic space. This allows the surgeon to insert their finger in the SOR and create space to place the reservoir.

A study in 2013 showed that there was a rising concern among surgeons when placing an IPP reservoir in patients after robotic-assisted laparoscopic prostatectomies (RALP) [18]. RALP require an intraperitoneal approach and robotic surgeons do not re-establish the peritoneal veil in the pelvis which allows the bowel to migrate to the prevesical space. Given that the number one indication for IPP placement is post-prostatectomy ED [7], the surgeon must take into consideration that the prevesical space may have excessive scar. Therefore, blind placement of the reservoir from a penoscrotal incision into the SOR can lead to catastrophic injuries which include bladder, small bowel injury, small bowel obstruction and intestinal fistula [19, 20].

To avoid incurring these risks, surgeons have proposed the use of an alternative or ectopic location. Ectopic location involves reservoir place-

ment between the transversus abdominis muscle anteriorly and the transversalis fascia posteriorly, rectus abdominis muscle anteriorly and transversalis fascia posteriorly, or subcutaneous below the Scarpas fascia [7, 21, 22]. While some use ectopic reservoir placement for patients with history of pelvic surgery, others have adapted and used this approach routinely [23, 24]. To do this, the index finger is placed through the external inguinal ring on top of the transversalis fascia and a space is created pointing to the ipsilateral shoulder. This space is then broadened and extended toward the shoulder using a ring clamp. Both the AMS Conceal™ low profile reservoir and Coloplast Cloverleaf® reservoir provide a ‘flat-like’ configuration that avoids palpation of the reservoirs when placed ectopically. Nevertheless, ectopic reservoir placement (ERP) has its own array of complications. We will briefly discuss complications that can occur during traditional SOR and ectopic placement of reservoirs. Table 48.1 summarizes the largest series reporting complications related to reservoir placement.

In a cadaver study, Henry and colleagues showed that a full bladder may be as close as 2 cm to the inguinal ring, while 6.75 cm while decompressed [25]. Therefore, the best way to avoid a bladder injury is to ensure that the bladder is empty prior to implantation of the reservoir. Various case reports have been published on patients with bladder perforation [26–31]. The largest series was reported by Furlow and Goldwasser who found erosion of the reservoir in a total of eight patients, six cases into the bladder and 2 cases into an ileal conduit (0.4%) [26]. Risk factors for visceral erosion include prior pelvic surgery and radiation. Patients with bladder erosion usually present with either gross hematuria or irritative voiding symptoms (Fig. 48.7) [27, 28]. A cystoscopy or imaging studies will confirm injury and depending on the extent of injury, the bladder defect should be repaired or a Foley catheter/suprapubic tube should be left in place until the bladder injury is healed.

Bowel injuries during or after reservoir placement are extremely rare. Documented cases have

presented with small bowel obstruction and intestinal fistula [19, 20].

Management of a bladder injury may be addressed without removal of the penile prosthesis. If the reservoir has eroded into the bladder, the reservoir may be removed with subsequent repair the bladder laceration and the reservoir can be relocated in the other side of the pelvis or in an ectopic location. On the other hand, bowel injury is more complex to manage. There are no studies of the proper management of this type of injury since it is extremely rare. Mulcahy recommends extension of the incision or a new incision to visualize the injury, resection of the involved bowel part and anastomosing the two bowel segments, while repositioning the reservoir elsewhere with copious wound irrigation [7].

The iliac vessels are about 3 cm lateral to the pocket where the reservoir is traditionally placed [25]. The vessels most commonly injured are the external iliac vein or branches such as the inferior epigastric, external superficial pudendal or cremasteric vessels. These vessels can be injured during placement or removal of retropubic reservoirs [17]. If copious bleeding is noted, vascular injury should be suspected, and the first step should be to ensure adequate exposure. Either the original incision is extended or a new incision should be made and the surgeon should consider an intraoperative consultation to a vascular surgeon who can aid with injury repair, if necessary. On many occasions, the surgeon removing the reservoir is different than the original surgeon who placed the initial implant. These situations can increase the risk of bleeding during reservoir removal which has led some surgeons to decide to leave the reservoir behind in uninfected IPP revisions (Fig. 48.8) [32, 33]. There have also been several reports of reservoir compression to the external iliac vein with subsequent lower extremity edema and deep venous thrombosis [17, 34–38]. If a traditional-SOR approach is undertaken, vascular complications can be avoided by ensuring that an adequate space has been created such that there is no compression to the adjacent venous structures. Whenever inadequate space is encountered, the surgeon should consider ERP.

Table 48.1 Studies regarding reservoir-related non-infectious complications

Author	Year	Study population	Follow-up	Study design	Reservoir location	Complication rate	Reservoir-related type of complications	Comments
Clavell-Hernandez et al. [77]	2018	974	Mean: 20.4	Retrospective, Multicenter	612 Ectopic 362 SOR	Overall: 1.6% Ectopic: 2.0% SOR: 1.1%	Ectopic: Reservoir leak (<i>n</i> = 4) Palpation/pain (<i>n</i> = 3) Tubing torsion (<i>n</i> = 3) Intraperitoneal (<i>n</i> = 1) SOR: Bladder erosion (<i>n</i> = 1) Tubing torsion (<i>n</i> = 1) Reservoir Herniation (<i>n</i> = 2)	Recommend filling AMS Conceal to >80 mL, and if using Coloplast Cloverleaf: 75 cc reservoir or under-filled 125 cc reservoir to avoid muscle discomfort
Capoccia et al. [69]	2017	246	Median: 28.7 months	Retrospective chart review	230 SOR 16 ectopic	3.2%	SOR: Inguinal BH (<i>n</i> = 4) Spigelian BH (<i>n</i> = 1) Reservoir Herniation (<i>n</i> = 2) Autoinflation (<i>n</i> = 1)	2 patients with prior pelvic surgery developed incarcerated inguinal BHs. 1 autoinflation, 3 BHs, 2 reservoir hernias in the virgin pelvis cohort.
Gupta et al. [23]	2017	240	30 months	Retrospective	Ectopic SOR	1.6%	Reservoir leak (<i>n</i> = 2) Bladder perforation (<i>n</i> = 2)	Both bladder perforations occurred on SOR placement after RP
Karpman et al. [71]	2015	759	Mean: 17.8 months	Prospective Multicenter	572 SOR 177 Ectopic 10 Other ^a	0.7%	Ectopic: Reservoir Herniation (<i>n</i> = 2) SOR: Herniation (<i>n</i> = 2) Autoinflation (<i>n</i> = 1)	Autoinflation secondary to capsular contraction.
Stember et al. [32]	2014	2687	48 months	Retrospective review	2239 SOR 447 Ectopic	2.3%	Ectopic: Palpable Reservoir (<i>n</i> = 2) Autoinflation (<i>n</i> = 2) Herniation (<i>n</i> = 6) SOR: Bladder injury: (<i>n</i> = 2) Herniation (<i>n</i> = 2)	No reported bladder injuries in the ectopic group vs <i>n</i> = 2 in the SOR group. No reported revisions for palpable reservoirs or autoinflation in SOR group.
Levine and Hoeh [17]	2012	>400	NR	Retrospective	SOR	NR	Bladder erosion (<i>n</i> = 1) Vascular injury (<i>n</i> = 2) Inguinal Hernia (<i>n</i> = 1) Reservoir herniation (<i>n</i> = 1)	Vascular injuries: EIV compression causing leg edema Bleeding from branch of EIV
Carson et al. [41]	2000	372	Mean 57 months	Retrospective	NR	2.4%	Autoinflation (<i>n</i> = 9)	Revision rate due to device malfunction was 17.5%
Furlow and Goldwasser [26]	1987	2023	NR	Retrospective	SOR	0.4%	Bladder Erosion (<i>n</i> = 6) Ileal conduit Erosion (<i>n</i> = 2)	All cases were salvaged successfully.

AMS American Medical Systems, Inc., BH bowel hernia, EIV external iliac vein, NR Not recorded, SOR Space of Retzius, RP radical prostatectomy

This was a follow-up series of Stember et al. in 2014 looking into only peritoneal placement of reservoirs

^aSurgical implantation of reservoirs under external oblique, anterior to muscle, or contralateral SOR with the prior reservoir left in situ



Fig. 48.7 Erosion of prosthetic reservoir within bladder which is noted as a filling defect within the bladder. (Dr. R Carrion, USF Health)



Fig. 48.8 Prosthetic reservoir in the pelvis adjacent to the bowel and iliac vessels. Extreme caution to surrounding structures should be taken during reservoir removal to avoid injury. (Dr. R. Carrion, USF Health)

48.3 Postoperative Complications

Although there have been dramatic breakthroughs and improvements in prosthesis design and implantation techniques over the years to decrease complications rates and improve dura-

bility and patient satisfaction, the principles in IPP placement remain well-established.

48.3.1 Hematoma

Bleeding and hematoma formation may contribute to postoperative complications following IPP placement. Hematomas typically develop in the scrotum which provides a substantial expansion for blood and other fluids to collect. One common source of hematoma formation is bleeding from the corporotomies. Utilizing stay sutures or running horizontal mattress sutures during closure of the corporotomies may reduce the risk of hematoma formation [39]. While hematomas are not devastating relative to other complications and may be managed conservatively, they may become problematic in the postoperative setting because they may cause scrotal pain, discomfort, and an increased length of observation or repeat office visits. In the literature, incidence of postoperative hematoma after penile prosthesis placement ranges from 0.2% to 3.6% [40–46]. In a study by Pozza and colleagues, an incidence of 22% was reported after their first 50 prostheses without the use of closed suction drainage (CSD). However, after incorporation of CSD, their overall hematoma formation rate after a total of 500 cases was 3.6% [40]. Table 48.2 summarizes the incidence and management of several series reporting postoperative hematoma.

There are several methods that can be adopted to decrease the risk of bleeding and hematoma formation. Some surgeons utilize a watertight closure for corporotomies with the use of interrupted horizontal mattress sutures, while others do not attempt this to avoid the risk of damaging the cylinders with a needle puncture [39]. Henry proposed application of a “mummy wrap” compressive dressing which provides scrotal compression in conjunction with partial cylinder inflation to achieve hemostasis and prevent hematomas [46, 47]. In one study, the use of compressive dressing alone resulted in a complication rate of 2.9%. Nevertheless, with the addition of closed drainage and partial device inflation, hematoma rate decreased to 0.9% ($p = 0.009$) [46].

Table 48.2 Studies regarding outcomes and management of hematoma formation

Author	Year	Study population	Follow-up	Study design	Hematoma rate	Drain vs no drain hematoma rates	Management	Comments
Pozza et al. [40]	2015	500	NR	Retrospective	3.6%	SRPP (0.4%) IPP without CSD (22%) IPP with CSD (5.6%)	Needle aspiration and observation.	Study included Semi-rigid prostheses rates. Revision rate due to hematoma: 0.2%
Garber and Bickell [42]	2015	600	NR	Retrospective	0.5%	All patients had CSD (removed POD#1)	Hematoma evacuation	Authors investigated delayed (>5 days) hematoma formation, not acute (<5 days) postop hematomas. Revision rate due to hematoma: 0%
Minervini et al. [44]	2006	504	Mean: 50 months	Retrospective	2&	NR	Conservative without drainage	Revision rate due to hematoma: 0%.
Sadeghi-Nejad et al. [43]	2005	425	Mean: 18 months	Retrospective	0.7%	All patients had CSD (removed POD #1 or 2)	NR	Revision rate due to hematoma: NR. Overall infection rate was 3.3%, not increased with use of drain.
Carson et al. [41]	2000	372	Mean 57 months	Retrospective	1.8%	NR	NR	Revision rate due to hematoma: NR
Goldstein, et al. [45]	1997	434	Mean 22.2 months	Retrospective	0.2%	NR	NR	Revision rate due to hematoma: NR
Wilson and Delk [46]	1996	917	NR	Case series (abstract)	1.8%	PD only: 2.9% PD and CSD: 3.6% PD, CSD and PIC: 0.9%	NR	Revision rate due to hematoma: NR

CSD closed suction drainage, IPP inflatable penile prosthesis, NR Not recorded, PIC Partial Inflation of Cylinders, POD post-operative day, SPP semi-rigid penile prosthesis

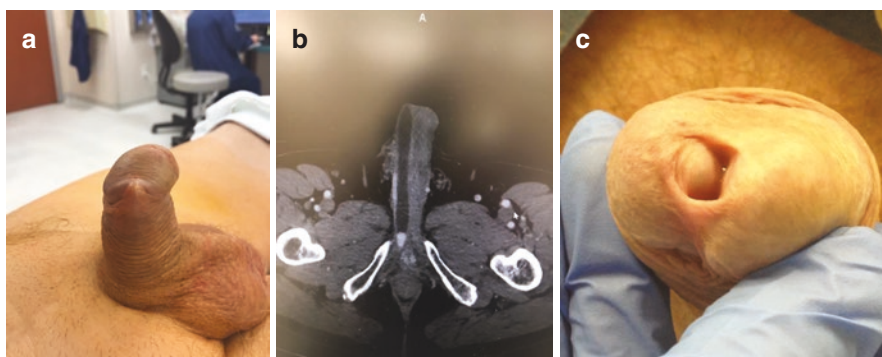


Fig. 48.9 (a) Lateral extrusion with impending erosion. (b) CT scan of the same patient. Notice thinning of the skin. (R.Wang, UT/MDA). (c) Impending distal erosion into the urethral meatus. (R. Carrion, USF Health)

Drain placement during IPP placement has been a topic of debate. Critics of drain placement believe it may increase infection rates, while proponents of closed drainage use argue that it in fact decreases post-operative hematoma complication rates without changing infection rates [46]. A multi-institutional study of 425 patients undergoing primary IPP implantation had a hematoma complication rate of 0.7% with the use of closed drainage with an infection rate of 3.3% which was comparable to the infection rates reported by other contemporary groups not using closed drainage [43]. Most recently, Morey's group proposed the use of oxidized regenerated cellulose (Surgicel®Fibrillar™, Ethicon, USA) in conjunction with closed drainage which helped reduce postoperative drain output and hence hematoma-related complications [48].

48.3.2 Impending Cylinder Erosion and Delayed Crossover

Reported revision surgery for IPP implantation is more commonly required for cosmetic issues and erosion problems as opposed to mechanical failure [47]. The most common source for device failure is fluid leak from the prosthesis whereas supersonic transport (SST) deformity, cylinder aneurysm deformity, cylinder crossover and impending lateral extrusion are less common [49, 50]. Although erosions and crossover are sometimes categorized as malfunction of the device,

these will be discussed in this section as a separate entity.

Impending cylinder erosion occurs when the cylinder has worked its way through the tunica albuginea and is pressing under the skin (Fig. 48.9a, b), the glans penis, or impinging upon the urethral meatus (Fig. 48.9c). It is usually the result of forceful dilation and tunical perforation during initial prosthesis implantation or mechanical pressure from the cylinder [7]. In the postoperative setting, patients with lateral extrusion and delayed crossover complain of pain during prosthesis inflation and penile curvature. These complications also put the patient at high risk for erosion. When dealing with these cases, it is important to determine whether the impending erosion is secondary to an underlying infection (look for presence of redness, induration or slight drainage) and distinguish between urethral/skin extrusion and frank erosion. Mulcahy proposed a distal corporoplasty for patients without erosion which involved a distal corporotomy to expose the fibrotic sheath around the prosthesis [51]. The fibrotic sheath is then incised and a new plane of dissection is developed with Metzenbaum scissors and dilators behind the sheath distally. (Fig. 48.10a) With the use of a Keith needle and a Furlow introducer, the cylinder is then redirected into the new cavity. The cylinder is then secured in proper position with the back wall of the original tough fibrotic capsule sheath and the tunica albuginea of the corporotomy closure.

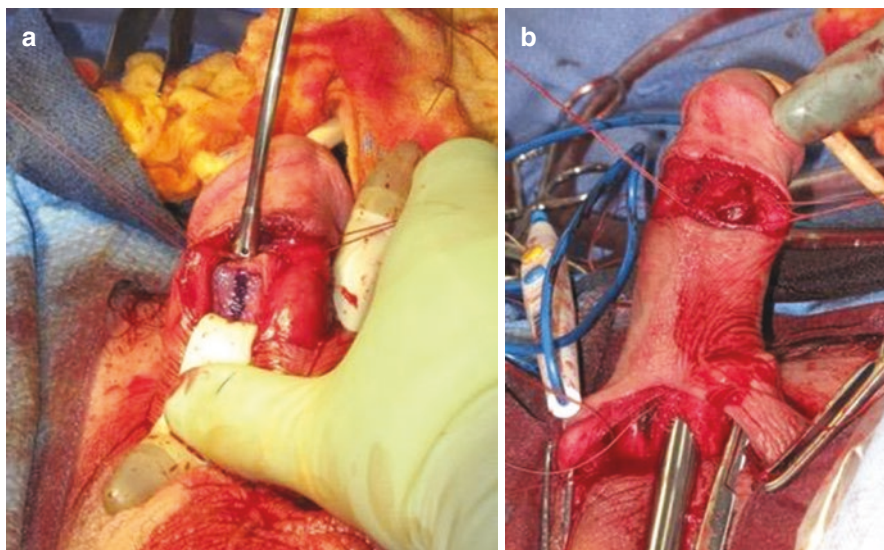


Fig. 48.10 Distal Corporoplasty. (a) A distal counter incision is made and a new intracorporal channel is created. Notice the capsule sheath covering the dilator. (b)

Dilator placed through penoscrotal corporotomy and navigated into the new and true intracorporal channel. (R. Carrion, USF Health)

(Fig. 48.10b) If the cylinder is impinging on the glans or urethra, an additional step is necessary. The distal aberrant tract of the capsule can be closed with a purse string using non-absorbable suture prior to redirecting the cylinder into the new cavity (Fig. 48.11).

The compelling novelty of Mulcahy's technique was the use of native tissue to overlap the cylinders. Prior to his publication, synthetic graft inlay was the most commonly used procedure which led to higher infection rates and longer operative time [52–55]. His method has been adopted and modified since the original description in 1999. The largest series was published by Carson and Noh three years later [56]. In their series of 28 patients, 18 patients managed with distal corporoplasty were compared to 10 patients managed with windsock repair using Goretex graft. When compared to windsock repair, patients undergoing distal corporoplasty had less operative time (mean 90 minutes vs 53 minutes, respectively). While there were no postoperative infections or recurrences in those undergoing distal corporoplasty, one patient who had a windsock repair had a postoperative infection and two had recurrences of extrusion (6 and 18 months after repair, respectively). The authors concluded that distal corporoplasty is an overall superior

method because of fewer major complications and reduced surgical time.

More recently, Antonini and colleagues reported a surgical technique which involves a distal corporal anchoring stitch to address distal crossovers and impending lateral extrusions [50]. This technique comprises of a lateral, longitudinal, and sub-coronal incision of 1 cm on the side where the 'crossover' cylinder should be positioned. A transverse corporotomy incision of the tunica albuginea is made and the distal aspect of the affected cylinder is delivered. A 4–0 PDS suture is then placed through the distal cylinder ring and a new, properly positioned intracorporal channel is created using Metzenbaum scissors and Hegar or Brooks dilators. The previously placed 4–0 PDS suture is passed through the distal end of the new channel using a Keith needle and Furlow. Finally, a small cruciate incision is made on the glans, at the location of the anchor stitch, the suture is tied down and the knot is buried in the glans tissue which creates a fibrotic process that fixes the prosthesis to the glans. The cruciate incision in the glans is closed with Dermabond (Ethicon, Cincinnati, OH, USA). In their series of 53 patients, 14 had distal crossover while 39 had lateral extrusion. There were no reported intraoperative complications and mean

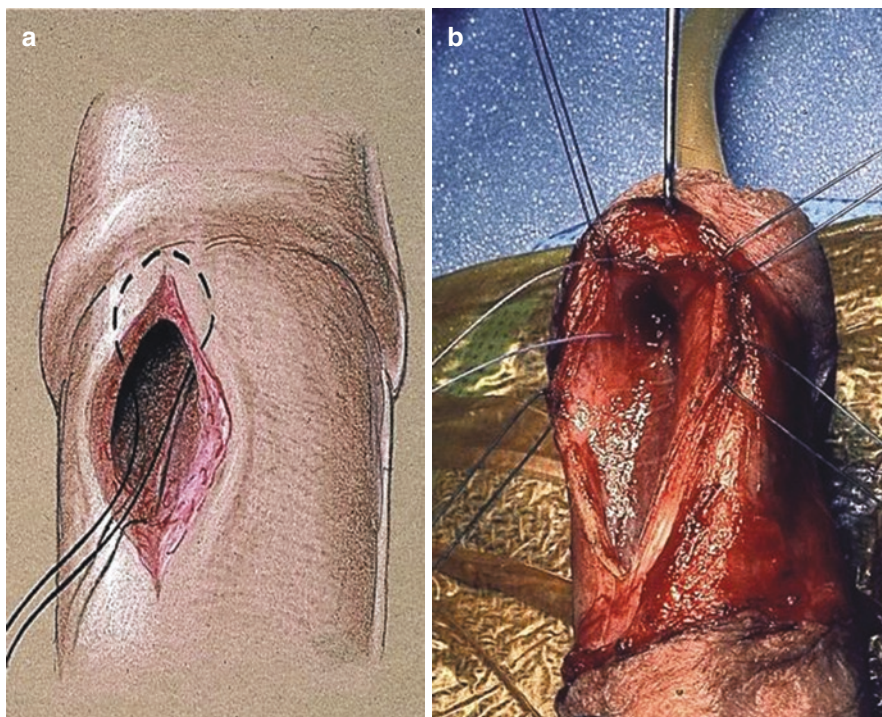


Fig. 48.11 Purse string suture is performed with non-absorbable suture prior to incising the back wall of the capsule to prevent urethra or glans impingement. (Courtesy: SK Wilson)

OR time was 69 minutes. After a median follow up of 46.8 months, satisfaction rate was high and there were no reported infections, wound-healing defects, or altered sensation. Although two patients (3.8%) reported recurrence of lateral herniation, none of the prostheses required replacement because of extrusion, mechanical failure or infection.

48.3.3 Glans Hypermobility (Floppy Glans Syndrome)

Floppy Glans Syndrome (FGS), more commonly referred to as glans hypermobility or unstable glans, is an uncommon complication which can create difficulty or pain with penetration during sexual intercourse in patients who have undergone IPP placement. FGS occurs when the glans is hypermobile despite an erection of the penile shaft. Its true incidence is difficult to determine given the uncommon nature of its occurrence, but has been noted to range between 0.004% and 0.9% [23, 57]. Bickell et al. [58] reported three main sub-

types of floppy glans which were classified based on the direction of the glans droop. Ventral droop was defined as *SST* (supersonic transport) *deformity* or *Concorde deformity*, both describing the deformity's resemblance to the former airplane's nose. The SST appearance is most often seen when the implant is improperly sized (too short) due to inadequate dilation. (Fig. 48.12a) Accentuation of the deformity secondary to exceedingly under-sized cylinders manifests as a flail penis. (Figs. 48.1 and 48.12b) However, *true hypermobility* of the glans, that which is evident even with properly sized cylinders, may be seen as a result of poor structural support of the glans by the tips of the corpora cavernosa (Fig. 48.12c). Although the available literature encourages the surgeon to perform immediate glans fixation for true hypermobility [59], some surgeons believe that in the case of a correctly sized cylinder placement, the subsequent capsule formation around the cylinder tip often corrects the problem without surgical intervention, and if the glans still remains hypermobile after healing, it can surely be corrected in a subsequent relatively-easy procedure [60].



Fig. 48.12 (a) SST deformity secondary to undersized cylinders or poor dilation during initial IPP placement. (b) Flail penis due to extremely undersized cylinders. (c) True

glans hypermobility despite adequate cylinder sizing. (d) Dorsal droop, or reverse SST, secondary to inappropriate cylinder placement or oversizing. (Dr. R. Carrion, USF Health)

The second FGS subtype is dorsal droop, also called reverse SST deformity. Dorsal droop is most commonly caused by oversized cylinders or inappropriate cylinder placement. (Fig. 48.12d) If not identified and corrected, this deformity may cause ventral protrusion which can lead to impending erosion. Lastly, the third subtype is lateral droop which is commonly seen after distal crossover as described in the previous section (Fig. 48.2a).

Treatment for FGS depends on the etiology of the patient's deformity. Even though some practitioners have advocated for conservative management which includes oral phosphodiesterase type 5 inhibitors, intraurethral alprostadil and/or

Trimix intraurethral gel as first line to achieve glanular tumescence, surgical correction remains the gold standard of treatment for FGS. It is important to note that the definitive surgical management of almost any subtype of FGS as a result of incorrect cylinder size or placement (i.e. crossover) is removal of both IPP cylinders and attempt of re-implantation. In 1980, Ball described his glanulopexy technique to correct ventral droop [61]. A dorsal subcoronal incision is made followed by dissection until Buck's fascia is identified under the glans, fixed and secured onto the more proximal tunica albuginea of the corpora cavernosa using permanent sutures (Fig. 48.13a, b). The surgeon must always be careful not to

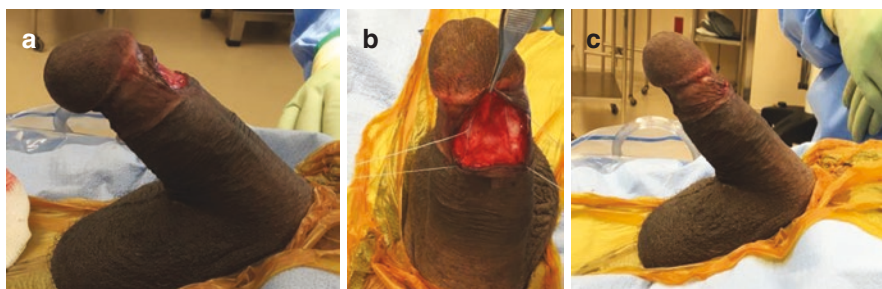


Fig. 48.13 Ball's glanulopexy: (a) Dorsal semilunar circumcission incision is made. SST deformity is appreciated. (b) Buck's fascia under the glans is sutured and secured to the more proximal tunica albuginea to correct SST. Notice

sutures and dissection is on the dorso-lateral aspect of the shaft to avoid injury to the NVB. (c) Incision is closed with absorbable sutures. SST deformity has been corrected. (R. Wang, UT/MDA)

injure the neurovascular bundle (NVB) or the underlying IPP cylinders. This is done grasping the tunical tissue with the teeth of an Adson forceps, and 'bunching it up' so that the needle can be passed without injuring the underlying cylinder [7]. The more superficial dartos layer is closed to cover and avoid palpation of the sutures, followed by skin approximation (Fig. 48.13c). Patient satisfaction rates after this technique approximate 90% [62].

At their institution, one of the authors (RC) favors an alternative technique which involves distal penoplasty for correction of ventral or dorsal droop. This approach involves placing clamps on the penile shaft on the opposite side of the droop to imbricate the skin and underlying Dartos fascia. Excess skin and Dartos fascia are excised in elliptical fashion and the remaining defect is closed in a transverse manner with interrupted absorbable sutures (Fig. 48.14). In their preliminary study of 10 patients, all were satisfied with no need for re-intervention [63].

Patients with lateral droop without crossover or dorsal droop with impending protrusion usually require distal corporotomy incisions and subsequent dilation through the true corporal cavernosa space as described earlier for patients with corporal fibrosis. If this does not result in correction of the deformity, the cylinders should be removed altogether and replaced in the correct position [58]. It is not uncommon that a combination of the above-mentioned approaches and techniques are utilized in conjunction in order to achieve the desired cosmetic outcome.

48.3.4 Glans necrosis

Penile glans necrosis, defined as ischemia to the glans secondary to compromised blood flow, is another very rare complication of IPP placement with devastating consequences to both the patient and the physician. Other than a few scattered case reports, there is only one study in the current literature that discusses the possible etiologies and outcomes on a series of patients with glans ischemia after penile prosthesis surgery [64]. With the understanding that the blood supply to the glans penis consists of the dorsal arteries and the terminal branches of the spongiosal arteries, it is possible that any condition or surgical maneuver that interferes with both of these will increase the risk of ischemia. In their cohort of 21 cases, all patients were found to have, on postoperative day 1, a dusky, congested and blistered glans on physical examination. Preoperative risk factors included arteriosclerotic cardiovascular disease (90%), diabetes (81%) and smoking history (81%). The most prevalent intraoperative and postoperative factor contributing to necrosis was subcoronal incision (86%), be it for a coincident circumcision or penile degloving. Other risk factors included penile wrapping with an occlusive elastic bandage (62%), sliding technique for Peyronie's disease (33%), and urethral mobilization (29%).

Wilson et al. [64] recommend immediate removal of intracorporal cylinders when a patient presents with a swollen, dusky, blistered or discolored glans penis in the early postoperative



Fig. 48.14 Distal Penoplasty for FGS: (a) Skin and Dartos fascia of the penile shaft are imbricated with Allis clamps on the opposite side of the droop. (b) Excess skin

and Dartos fascia are excised in elliptical fashion with a notably large defect. (c) The defect is then closed transversely with interrupted absorbable sutures. (d) Final result with correction of SST. (R. Carrion, USF Health)

period following IPP implantation. When treated conservatively with observation, glans necrosis developed with resultant glanular loss in all cases. Patients with preoperative risk factors and comorbidities should not undergo the high-risk adjunctive surgical maneuvers previously mentioned. Ultimately, in patients warranting these high-risk maneuvers (e.g. severe Peyronie's disease), the authors recommend a non-degloving approach to minimize the risk of glans ischemia

while still providing adequate surgical exposure [65, 66].

48.3.5 Pump-related complications

Pump complications requiring revision include erosion, migration and pump adherence. Most of the time, pump erosion occurs as a result of infection and manifests as pump fixation and eventual



Fig. 48.15 Pump erosion without gross signs of infection. (R. Carrion, USF Health)

breaking through the skin with purulent discharge. However, erosion may also result from not having enough Dartos tissue covering the pump during closure which, in combination with excess friction, can cause the pump to erode through the scrotal skin without gross signs of infection (Fig 48.15). Traditionally, these patients would require removal of the entire device, but there are a few cases that have been successfully managed with removal and replacement of the pump only [67].

When a patient presents with the inability to squeeze the pump to activate the IPP, it is likely he has pump adherence or ‘frozen pump’. Although it may be classified as a device malfunction, we will include this complication in this section due to its various etiologies. If the patient spends a significant amount of time without activating or cycling the device, the valve within the pump may “dry out” and prevent him from squeezing the pump. Most of the time, this requires a visit to the physician who may attempt ‘re-lubrication’ by squeezing the pump as hard as possible (for Coloplast devices) or rapidly and repeatedly squeeze the pump and deflate button (for AMS devices). In order to prevent recurrence, it is important that the patient cycles the penile implant regularly [68].

Another cause for pump adherence results from a hyperbolic inflammatory response around the pump which generates the formation of an extremely thick capsule. Although there is no

supporting literature, it is believed that this excessive tissue reaction is possibly secondary to an unrecognized laceration of the tunica vaginalis during implantation [67]. The consequence of this problem is inability to manipulate the pump along with a poor cosmetic outlook. (Fig. 48.16) These cases are managed by surgical excision of the capsule, thorough washout, and repositioning versus removal and replacement of the pump.

Lastly, the pump can migrate to the perineum, proximal shaft or any other unfavorable location within the scrotum which may hinder the patient from accessing the pump for comfortable activation. Unfortunately, if the physician is unable to re-accommodate the device in a favorable location in the clinic, these patients will require surgical revision.

48.3.6 Autoinflation

Autoinflation is a rare reservoir-related complication after IPP placement. Historically, this complication has been categorized as device malfunction and was estimated to occur in up to 5% of total prosthetic surgeries, but the development of the lockout valves on the current pumps and reservoirs have reduced the incidence to less than 1% [32, 41, 69–71]. Although it is typically a bothersome or embarrassing mechanical problem, it may also result in more severe consequences such as cylinder erosion. Kobayashi and colleagues published a case in which the right cylinder eroded through the corpora caused by chronic cylinder pressure secondary to autoinflation [72].

Autoinflation occurs when the fluid pressure within the reservoir exceeds the back-pressure limits of the prosthetic pump assembly. If the pressure remains elevated for a sufficient length of time, the fluid will fill the cylinders and cause them to auto-inflate. The most common cause for autoinflation is insufficient space created for the reservoir at the time of placement, although some have proposed capsular contraction and incomplete emptying of the cylinders in the post-operative period as potential instigators [17, 73].

In the 1990s, German physicians routinely placed prosthetic reservoirs in the peritoneal cav-

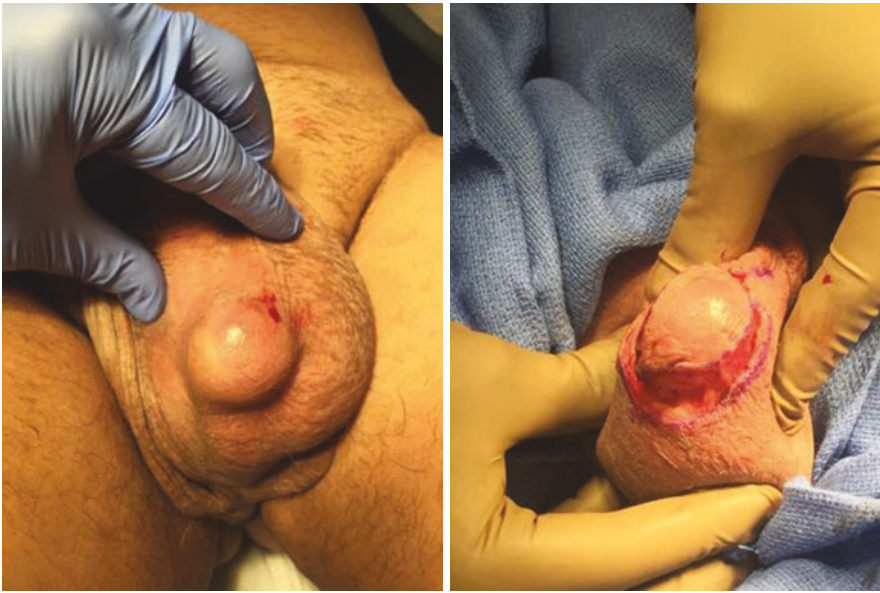


Fig. 48.16 Pump adherence requiring excision and pump replacement. (R. Carrion, USF Health)

ity to avoid auto-inflation. Foreign bodies placed in the peritoneal cavity do not stimulate capsule formation, and therefore transmission of intraabdominal pressure to the reservoir is precluded. Nowadays, with the availability of the reservoir and pump lock out valves, and feasibility of ectopic placement, intraperitoneal placement of reservoirs is discouraged by most high-volume implanters.

Management of auto-inflation involves either capsulotomy or reservoir repositioning. Abbosh et al. described a technique which involved laparoscopy to identify the reservoir and open the capsule. Patients were then advised to keep the IPP completely deflated for 3 weeks following the procedure [74].

48.3.7 Herniation

Reservoir migration through the inguinal canal is unusual with a reported incidence ranging from 0.09% to 0.7% in SOR placement and 1.4% in patients undergoing ERP [32, 75]. Repetitive Valsalva maneuvers, such as coughing or straining which create pressure in the abdominal cavity, may cause extrusion of the reservoir to the inguinal canal and scrotum (Fig. 48.17). Other

risk factors include a patulous external inguinal ring identified at surgery, obesity, respiratory disorders and smoking. Sadeghi Nejad and colleagues reported results of a questionnaire sent to members of the Society for the Study of Impotence which assessed reservoir migration from the SOR to the inguinal canal or scrotum. A minority of respondents (28%) had experienced this problem, and although they felt to be a very rare complication, herniation appeared in the immediate postoperative period and was often associated with coughing spells or vomiting [75]. This is the reason most surgeons recommend to avoid any strenuous activity in the early postoperative period.

Management of reservoir herniation usually consists of reservoir replacement or repositioning through an inguinal incision with repair of the defect [75]. When placed ectopically the reservoirs should be placed at least 4 inches above the inguinal canal and filled to almost capacity to avoid migration through the external inguinal ring [7]. Another technique that is used to avoid reservoir migration involves applying a purse-string suture around the inguinal ring in patients at risk for herniation [71]. Morey et al. described an approach of high sub-muscular ERP using long, angled, Foerster lung grasping clamp which



Fig. 48.17 Reservoir Herniation. Reservoir has migrated to the left groin. (R. Carrion, USF)

decreases the incidence of reservoir herniation by requiring that the reservoir travels a longer distance. In their 2-year experience of 158 implants including IPPs and artificial urinary sphincter pressure-regulating balloons, patient satisfaction was above 95% and there were no reports of revision secondary to reservoir herniation [21, 76]. More recently, Dr. Wilson has developed an ectopic reservoir insertion tool (Sontec, Centennial, CO, USA) which prevents enlargement of the implant incision when spreading and permits high sub-muscular placement of the reservoir to prevent herniation.

48.3.8 Emerging Complications with Ectopic Reservoirs

ERP has become a well-accepted technique for patients with a history of pelvic surgery. Due to its somewhat recent implementation, some surgeons wondered what type of complications will ectopic placement bring and what will the surgical experience be to retrieve reservoirs from the sub-muscular space [71]. Some surgeons avoid

ERP due to palpability at the abdominal wall and potential patient dissatisfaction. Karpman et al. [18] showed that 79% of surgeons and patients find a bulge in the reservoir area without affecting patient satisfaction (85.9% with ERP vs 81% in SOR), which suggests that palpability is not an adverse outcome in patients undergoing IPP with ERP [18]. Moreover, most available series have reported low rates of revision for reservoir palpability [21, 32, 71].

The authors recently published a multi-institutional 5-year experience with 612 patients undergoing IPP with ectopic reservoir placement [77]. An incidence of 2.0% ($n = 12$) of complications requiring revision surgery were reported. The most common complication noted was reservoir leak of the AMS Conceal™ reservoir ($n = 5/12$) caused by inward folding and subsequent leakage at the point of maximal weakness of the disc-shaped reservoir (Fig. 48.18a, b). Another rather unusual complication was torsion of the reservoir's tubing, also referred to as the 'telephone-cord syndrome', which prevented patients from inflating the device and was noted in 3 cases using the AMS 700 device (Fig. 48.18c). Three patients required revision secondary to pain at the reservoir area which were managed with an incision at the reservoir area and ensuing repositioning. To avoid these complications the authors provided several recommendations. When using the AMS device, the Conceal™ reservoir should be filled with at least 80 mL to prevent inward folding. If using the Coloplast penile prosthesis, the surgeon should use a partially-filled 125 mL Cloverleaf reservoir or a 75 mL reservoir to avoid palpation and muscular discomfort. Moreover, patients should be informed of the possibility of reservoir-related abdominal muscular pain which may require subsequent reposition.

As stated before, when removing the penile prosthesis for noninfectious reasons, there are conflicting opinions in choosing to remove the entire three-piece prosthesis or leaving the reservoir in place. But when the problem is the reservoir, this may pose a challenge for removal due to its high location in the abdominal wall, possible migration, and the uncertainty of making a second incision to obtain the reservoir. There is no standard tech-

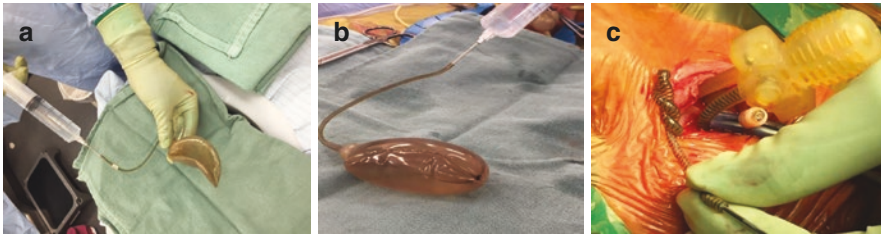


Fig. 48.18 (a) Inward folding of the 'disc-shaped' AMS Conceal reservoir. (b) Inward folding of the reservoir revealing point of maximal weakness causing leakage

defect. (c) Reservoir tubing torsion (a.k.a 'telephone cord syndrome') which prevented inflation of cylinders. (R. Wang, UT/MDA)

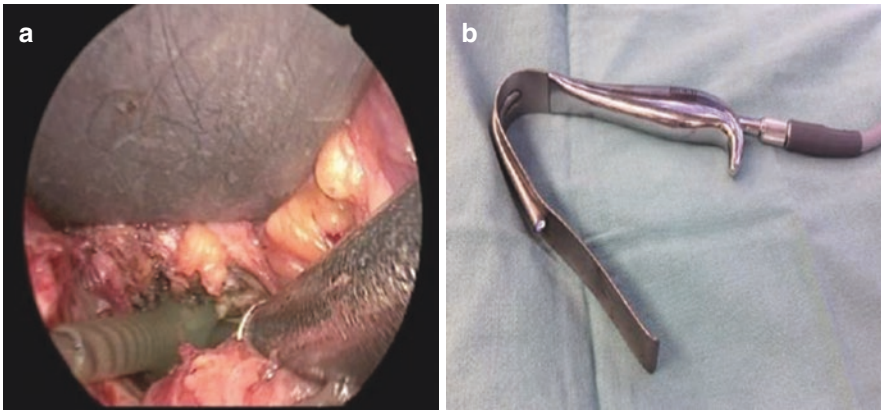


Fig. 48.19 (a) Ectopic reservoir removal with use of laparoscopic instruments. A 30-degree laparoscopic lens was used. A hand-held lighted breast retractor was used for deep retraction purposes and light source (on top of the image). With the guidance of the camera, a 5 mm

Harmonic, 5 mm Ligasure and laparoscopic scissors were used to create a slow and gentle dissection cephalad along the tubing toward the reservoir. (b) Hand-held lighted breast retractor. (R. Wang, UT/MDA)

nique established to remove the reservoir during explantation of the IPP. Staller et al. [78] published a technique which involved the utilization of laparoscopic instruments to remove the reservoir in the high submuscular location (Fig. 48.19a), although our experience has shown that hand-held lighted retractors (e.g. lighted breast retractor) (Fig. 48.19b) have been of great assistance for removal of reservoirs without requiring a second incision or additional instrumentation.

48.3.9 Device Malfunction

Device malfunction can occur for a variety of reasons, some of which have already been mentioned in previous sections, including leakage from the reservoir, tubing or cylinders, autoinfla-

tion, cylinder aneurysm and pump malfunction. All these complications have motivated the penile prosthetic companies to continue pursuing improvements in their products' design. These include the development of kink-resistant tubing, antibiotic coatings, lock-out valves to prevent autoinflation of the cylinders and modifications to the size and shape of the reservoirs, among others [17, 47, 79]. Table 48.3 summarizes some of the largest studies reporting complications to device malfunction.

As with any other prosthetic device, mechanical function of the IPP is expected to decline over time. Kim et al. [80] determined mechanical survival rates to be 97.6%, 93.2%, and 78.2% at 3, 5, and 10 years, respectively. Another more recent study found prosthesis survival rates of 90.8% at 5 years and 85.0% at 10 years [81]. The study

Table 48.3 Studies regarding outcomes and management of device malfunction

Author	Year	Study population	Follow-up	Study design	Rate of malfunction	Type of malfunction	Management	Comments
Gupta et al. [23]	2017	240	30 months	Retrospective	4.5% (n = 11)	Frozen pump (n = 5) Reservoir leaks (n = 2) Cylinder leak (n = 1) Cylinder aneurysm (n = 3)	Capsulotomy for frozen pumps. Replacement for all others.	Malfunction survival rate: 5 years: 95.4%
Grewal et al. [83]	2014	2263	Mean 7.5 mo	Retrospective	3.9%	Non infectious failure	Revision	Inflatable: 4.17% revision rate of 1824 cases Semirigid 2.96% of 439 cases 16.4% revision due to malfunction
Chung et al. [81]	2013	955	Mean: 76 months	Retrospective	19.2%	Fluid loss (75%) Autoinflation (10%)	Device <5 years: Replacement of single component Device >5 years: Replacement of all components	Over-all IPP survival rate: 5 years: 90.8% 10 years: 85%,
Kim et al. [80]	2010	397	Mean: 113 months	Retrospective	20.6%	Cylinder leakage (n = 57) Reservoir tear (n = 10) Connector tube leak (n = 8) Pump failure (n = 4) Other (n = 3)	Revision	Overall IPP survival rate: 3 years: 95% 5 years: 91% 10 years: 75.5%
Wilson et al. [82]	2007	2384	15 years.	Retrospective	10 yrs: 20.6% 15 yrs: 28.8%	Fluid leakage Cylinder breakage Cylinder deformity Tubal breakage Other Pump defect Other Reservoir defect	Revision	Mechanical survival rate: 5 years: 88.9% 10 years: 79.4% 15 years: 71.2% Overall IPP survival rate: 5 years: 79.1% 10 years: 68.5% 15 years: 59.7%
Carson et al. [41]	2000	372	Mean: 57 months	Retrospective	17.5%	Fluid loss (n = 40) Autoinflation (n = 9) Extrusion (n = 5) Erosion (n = 5) Other (n = 7)	Revision	Extrusion and Erosion were reported as device malfunction.
								Mechanical survival rate: 3 years: 92.1% 5 years: 86.2%

IPP inflatable penile prosthesis

with the largest cohort ($n = 2384$) and longest follow-up (15 years) was published by Wilson et al. in 2007 [82]. Revision-free survival rates relating specifically to device malfunction were found to be 79.4% and 71.2% at 10 and 15 years, respectively. This study concluded that the IPP is one of the most dependable medical devices implanted into humans.

Management of device malfunction usually consists of removal and replacement of the affected IPP components. If the IPP has been in place for a period greater than 1 year, it is recommended to replace all parts due to wear on the device material [7]. Also, it is wise to wash the cavities thoroughly with antiseptic solutions to destroy any bacteria hiding in biofilm before replacing a new implant [12].

48.4 Conclusion

We have discussed several techniques, approaches and strategies that an implant surgeon should be familiar with to manage and minimize complications and improve patient outcomes. Unfortunately, prosthetic urologists do not always willingly share all of their complications following IPP implantation, thus rendering any truly comprehensive data collection of the true incidence of the more serious of complications. The majority of studies reporting non-infectious complications during penile prosthesis surgery are retrospective. These give us a historical perspective of overall low rates of complications especially with adherence to standard precautions and protocols, and most of them generally provide a guide to incorporate new modifications to preclude such obstacles. We believe the best way to approach these situations is through informative preoperative counseling to set proper expectations and discuss that penile prosthesis placement, like any other surgery, has a risk of complications. No promises, guarantees, or unrealistic expectations should be given to patients because despite improvements in surgical technique and prosthetic device design, complications can occur, and prosthetic surgeons should be well prepared to handle them.

Key Summary Points

- The best approach to prevent crossover is to always keep in mind the dorsolateral angle during corporal dilation.
- If proximal perforation occurs, methods to keep the cylinder base from migrating down through the defect and allow the perforation to scar over the base of the cylinder include the use of a RTE sling and/or fixating the input tubing with the stay sutures at the level of the corporotomy.
- Distal or urethral perforation can be avoided by firmly squeezing the glans immediately proximal to the glans during dilation in an infrapubic approach and during manual modeling for Peyronie's disease.
- During reservoir placement, the best way to avoid a bladder injury is to ensure that the bladder is empty prior to implantation of the reservoir. If copious bleeding is noted, vascular injury should be suspected, and the first step should be to ensure adequate exposure.
- To decrease the risk of bleeding and hematoma formation, surgeons may utilize a watertight closure for corporotomies, application of a "mummy wrap" compressive dressing or placement of a drain.
- Prior to considering a distal corporoplasty for an impending erosion, it is important to determine whether the impending erosion is secondary to an underlying infection (look for presence of redness, induration or slight drainage) and distinguish between urethral/skin extrusion and frank erosion.
- When a patient presents with a swollen, dusky, blistered or discolored glans penis in the early postoperative period following IPP implantation, glans ischemia should be suspected and immediate removal of intracorporal cylinders is recommended.

- Management of reservoir herniation usually consists of reservoir replacement or repositioning through an inguinal incision with repair of the defect.
- Emerging reservoir-related complications include torsion of the tubing and revision secondary to discomfort when placed ectopically. It is recommended to fill Conceal reservoir with at least 80 mL to prevent inward folding and subsequent leakage.

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Dual Implantation of Inflatable Penile Prosthesis and Artificial Urinary Sphincter or Male Sling: Benefits and Risks

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Acronyms

AUS	artificial urinary sphincter
ED	erectile dysfunction
IPP	inflatable penile prosthesis
MUS	male urethral sling
SUI	stress urinary incontinence

implantation can undoubtedly offer great reward, this strategy requires prudent patient selection and attention to detail. As such, we review the literature to discuss important aspects of pre-operative planning, intraoperative technique, and post-operative management to minimize complications and ensure successful outcomes.

49.1 Introduction

After treatment for lower urinary tract malignancy, erectile dysfunction (ED) and stress urinary incontinence (SUI) are common complaints that can coexist in many patients. After diagnosis, patients are typically initiated on conservative treatments with varying success. Should these options fail, motivated patients will ultimately require either synchronous or nonsynchronous combined prosthetic implantation for definitive repair. While dual device

49.2 Artificial Urinary Sphincter and Penile Implant Surgery

49.2.1 Patient Selection

The first step in successful treatment of ED and SUI is prompt and proper diagnosis. Due to the discomfort of broaching the topics of sexuality or urinary concerns held by male patients, clinicians should initiate screening for these conditions during follow-up after pelvic surgery and radiotherapy. After prompt diagnosis, patients should be initiated on proven treatment pathways and followed closely for progress.

Before considering prosthetic repair, patients with ED should be informed of the myriad of treatment options including surgical and non-surgical treatment options such as lifestyle modification, oral phosphodiesterase-5-inhibitors, vasoactive intraurethral or intracavernous injection therapy, and the vacuum-erection-device. In patients who are refractory or dissatisfied with

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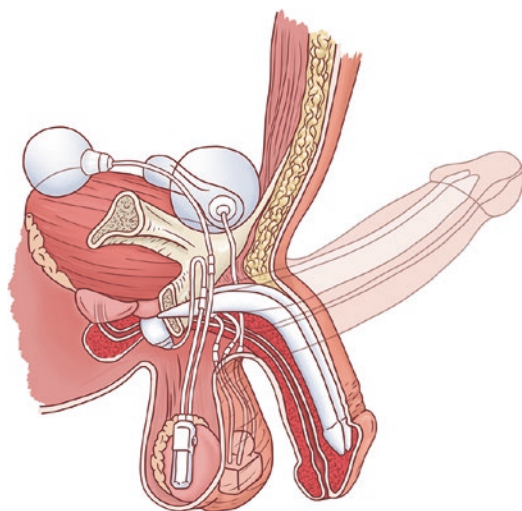


Fig. 49.1 Final positioning of all components of artificial urinary sphincter and three-piece inflatable penile prosthesis after placement

conservative therapies, penile implant surgery should be offered expeditiously.

Patients with SUI should be treated with a similar approach. After pelvic surgery, patients should be given sufficient time to allow their inherent intrinsic sphincter to function and be encouraged to perform Kegel exercises. If incontinence persists, pelvic floor physical therapy and biofeedback should be initiated. In patients who continue to have an unacceptable degree of incontinence, surgical options, such as the AUS and male urethral slings, should be discussed.

In patients with concurrent refractory ED and SUI, patients should be offered single or dual prosthetic repair after a careful assessment of comorbid medical and psychosocial conditions, surgical history, and after a discussion of risks, benefits, and desired outcomes (Fig. 49.1).

49.2.2 Pre-Operative Preparation and Surgical Site Infection Prevention

Surgeons should adhere to protocols designed to prevent surgical site infection that includes use of an antiseptic cleansing agent pre-operatively. Prior to prosthetic implantation, patients are

screened for MRSA colonization and treated with intranasal mupirocin when indicated. On the day of surgery, atraumatic hair removal, drainage of the urinary bladder, and alcohol-based skin preparation and scrub are performed before incision. Broad spectrum intravenous antibiotics are administered for infection prophylaxis when multicomponent prosthetics are implanted.

49.2.3 Timing of Device Placement

When considering implantation of two prosthetic devices, the first step in pre-operative planning is deciding if devices will be placed during the same surgical setting or in a staged manner. Over the past two decades, there have been several studies describing the feasibility and safety of dual device placement with many prominent implanters supporting synchronous placement using a single scrotal incision and to avoid two separate anesthetic events. While this approach was popularized in the late 2000s, synchronous device implantation has fallen out of favor due to several factors including recent studies showing the potential increased risk of AUS erosive complications, abandonment of the penoscrotal approach for AUS placement, and the reduction in Medicare reimbursement for synchronous AUS and IPP placement in the United States. Nevertheless, timing continues to be a debated topic and worthy of the following in-depth discussion.

49.2.4 Synchronous Placement

Synchronous placement was first described in 1989 by two separate studies. The larger series by Parulkar and Barrett indicated that in their series of 65 patients with both devices, 40 patients underwent single-stage penile implant and urinary sphincters implantation. They found that patients with both devices achieved acceptable technical and functional outcomes [1]. During the same time, Marks and Light also reported in a separate study that among 37 patients who underwent AUS implantation for post-prostatectomy

incontinence, 4 patients underwent synchronous insertion of a penile implant without complication [2]. While technically feasible, two incisions were required and combined placement was not widely adopted or reported thereafter.

It was not until the introduction of the upper transverse scrotal incision for AUS placement by Wilson et al., that synchronous implantation became popularized. In their study, they introduced two important concepts: (1) the bulbar urethra could be accessed through a single scrotal incision and (2) all components of a 3-piece IPP can be placed during the same setting [3]. Of their 37 patients, 12 patients underwent combined device implantation. Of those 12 patients, 1 patient experienced infection of their penile prosthesis which required its removal. After this landmark study, Kendirci et al. performed a multi-institutional, retrospective analysis of 22 patients undergoing synchronous IPP and AUS implantation through a single trans-scrotal incision and found that after mean follow-up of 17 months, no prosthetic infections occurred. Functional outcomes were 4 patients experienced complications (urethral erosion, $n = 2$, reservoir migration, $n = 2$) [4]. Aside from achieving acceptable technical outcomes without an increased risk of intraoperative complications, Manicini et al. showed that patients undergoing dual implantation achieved similar improvements in satisfaction, penile rigidity, and continence compared to patients undergoing single prosthetic reconstruction [5]. They also showed that when both devices are placed simultaneously, patient confusion or difficulty of use did not appear to be issues in follow-up.

In addition to demonstrating its safety and promising functional outcomes, these initial studies also espoused the advantages of synchronous placement including using a single anesthetic event with its associated increased cost savings and shorter overall recovery. Sellers et al. showed that single-stage dual implantation significantly reduced operative times compared to the sum of individual implant procedures as well as cost without an increased risk of prosthetic infection or erosion⁶ (Table 49.1). With these observations, Al-Shaiji nicely outlined the arguments for and

Table 49.1 Comparison of mean operative times [6]

Procedure	<i>n</i>	Mean operative time (min)	SD	Range (min)
IPP	92	78	24	45–125
AUS	21	72	22	35–155
Dual IPP/AUS	15	113	33	72–162

IPP inflatable penile prosthesis, *AUS* artificial urinary sphincter

against staged and concurrent placement in his review as shown in Table 49.2 [7].

Encouraged by these initial studies, several institutions have continued to report retrospective studies which show acceptable outcomes utilizing a single scrotal incision and technique as depicted by Moncada [8]. Rolle et al. found in their study of 23 patients who underwent implantation of a penile prosthesis and artificial urinary sphincter, patients (15) who underwent synchronous implantation experienced similar outcomes as those patients (8) who underwent staged implantation [9]. Likewise, Martinez-Salamanca et al. reported that in their study population of 32 patients who underwent combined implantation, 96% of patients achieved social continence and an erection sufficient for intercourse after one year of follow-up [10]. Most recently, Bolat et al. reported that in their study of 14 patients who underwent synchronous implantation of a 2-piece inflatable penile prosthesis and artificial urinary sphincter, patients enjoyed a mean pad reduction of 4 pads down to 1 [11]. No intraoperative complications were reported in these series.

While the results of the above studies are encouraging they are limited by duration of follow-up. In addition, the initial excitement surrounding single-stage, single incision technique has become tempered after concerns were raised about the success of trans scrotal AUS placement versus traditional perineal placement. This question was first raised by Henry et al. who found that in their single center study with long-term follow-up, patients who underwent perineal-approach AUS placement had higher completely dry rate and underwent fewer subsequent tandem cuff placement than patients who underwent cuff placement through a penoscrotal incision [12].

Table 49.2 Comparison between advantage and disadvantage of synchronous and nonsynchronous dual prosthetic insertion [7]

Synchronous dual implantation	Sequential dual implantation
<i>Advantages</i>	<i>Advantages</i>
(i) Single incision (ii) Faster operating time (iii) Single anaesthetic event (iv) Shorter hospital stay (v) Decreased overall recovery time (vi) Increased cost savings (vii) Theoretical reduction in the infection risk (viii) Supine position allowing more mobility of the bulbar urethra facilitating posterior dissection (ix) Easier placement of the AUS pump (x) decrease in the risk of AUS pump migration	(i) More time allowed for a patient to accommodate the first device before considering a second implant (ii) Theoretical decreased initial confusion to operate the device (iii) For AUS, there appears to be a higher completely dry rate and fewer subsequent tandem cuff additions when placed at a more robust proximal bulb of the urethra during a perineal incision
<i>Disadvantages</i>	<i>Disadvantages</i>
(i) Sufficient patient dexterity needed to activate either pump as required (ii) theoretical concerns of patient confusion and difficulty of use with two scrotal pumping devices (iii) surgeon experience and learning curve. Requires more experienced prosthetic urologists (iv) if the bulbar urethra is considered difficult through the scrotal incision, the surgeon should use the perineal incision for the cuff placement (v) Infection would potentially necessitate removal of both implants components (vi) Concerns over the extent of dissection which may further increase the risks of erosion and infection (vii) Distal placement of the AUS cuff on the thin urethra may be less effective, with a higher early failure rate and revisions due to loosely fitting cuffs and accelerated urethral atrophy	(i) Two incisions (ii) Previous prosthetic implant may have asymptomatic colonization of the prosthetic device predisposing to infection during insertion of the second implant (iii) Extra care is needed to avoid damaging the components of the existing implant and its tubing (iv) Added danger of operating in an area with surgical scarring (v) Insertion of the sphincter pump from an abdominal incision can be associated with excessive edema or hematoma causing the pump to retract into the upper groin, making long-term use by the patient difficult (high riding pump)

These findings were then supported in a subsequent multicenter study which found a similar discrepancy [13]. It was thought that the reason for these differences in continence outcomes was that the penoscrotal approach resulted in cuff placement on the urethra that was too distal, where the corpus spongiosum was thinner. Subsequently, anatomical and manometric comparisons were then performed in a cadaveric study by Anusionwu et al. who found that the perineal approach offers a more proximal cuff location and, as a result, a more robust urethral size and improved urethral coaptation than the trans-scrotal approach [14]. Based on these findings, the penoscrotal approach for AUS placement has been largely abandoned in the United States and thus several of the cited advantages of synchronous placement have become less relevant such as supine positioning and use of a single incision.

In addition to suboptimal cuff location, disadvantages of synchronous placement include surgical complexity, possible patient confusion with both pumps in place, and the theoretical scenario of infection involving both devices which would require both prostheses to be removed. It is important to mention that this presumed risk of infection is based on conjecture rather than supported by published results. Aside from these significant surgical-based factors, synchronous placement has become less financially practical in the United States due to the reduction in reimbursement when both devices are placed during the same operative setting that occurred in 2014 by Center for Medicare and Medicaid Services.

Nevertheless, there continues to be a role for synchronous placement under select situations. While we have never been strong proponents of combined, single stage implantation, our experi-

ence has shown that there is no increased risk of intraoperative and post-operative device-related complications based on our own institutional analysis of patients with history of radical cystoprostatectomy and orthotopic ileal neobladder undergoing synchronous prosthetic reconstruction. This mirrors the experience of Segal et al. who found that patients with history of radical prostatectomy who underwent single stage dual prosthetic implantation experienced no increased risk of adverse events compared to those who underwent staged implantation. The favorable outcomes seen in both our studies may be partially attributable to use of two-incisions to place devices, with the AUS proceeding through a perineal incision and IPP through an infraumbilical or penoscrotal incision.

Based on this, we suggest that if synchronous placement is chosen, surgeons should inform the patient of the risks of simultaneous placement and follow technique as outlined by the studies by Segal et al. and from our own institution in which the AUS cuff is placed first and via a perineal incision to allow for optimal placement of the cuff around the bulbar urethra [15, 16]. It has been our experience, and that shared by others, that dissection and mobilization of the urethra is easier when penile cylinders are not in place. After successful implantation of the AUS, IPP placement can proceed as outlined in other chapters in this text. While our preferred location for alternative reservoir placement is in the retroperitoneum, prosthetic reservoirs can be placed in sites at the discretion of the implanting surgeon. Lastly, pumps are placed towards the midline but in separate subdartos pockets just lateral to midline.

49.2.5 Staged Device Implantation

While two separate anesthetic events are required, staged implantation is now the approach favored by most high-volume implanters in the United States. From a patient standpoint, single device implantation allows a patient to fully recover and become facile in using a prosthetic device including manipulating a control pump in the scrotum. Anecdotally, patients are more open to prosthetic repair after achieving a successful outcome with

one device and the learning curve for using the second device is often abbreviated after mastery of the first device. We also believe that the theoretical disadvantages of staged implantation are largely speculative including the risk of damaging the existing device. Nevertheless, implanting a prosthetic device in a patient with an existing device should be undertaken only by experienced surgeons who are facile in implanting and revising both devices.

The two questions surgeons must consider are timing and sequence of implantation. The order of device placement is dependent on what is most bothersome to the patient. In our experience, patients presenting with coexistent ED and SUI are typically bothered most by urine leakage and will seek to correct this first. An incontinence-first approach helps to minimize climaturia and decreases patient dependence on protective garments and pads prior to restoring their sexual function. We have also found that patients who were not initially interested in treating erectile dysfunction during consultation for incontinence will sometimes pursue treatment for sexual dysfunction after improvement in urine control. An AUS-first approach also avoids the fibrosis that is sometimes encountered during dissection and mobilization of the urethra with penile prosthesis cylinders in place. When an AUS is placed after a penile implant, care must be taken to avoid urethral injury during urethral dissection.

While there is no prescribed minimum time between prosthetic implantation, our preference is to wait at least 3 months between surgeries. In patients with urethral risk factors such as a history of pelvic radiotherapy, we typically wait 6 months before implanting the second device to minimize the risk of urethral erosion. This allows the urethra time to recover from the vascular insults of urethral mobilization or corporal cylinder implantation.

49.2.6 IPP Placement After AUS Placement

In patients with an existing AUS, we follow an erosion-prevention protocol during subsequent

IPP placement that starts with a diligent pre-operative assessment of what sphincter components the patient currently has (i.e. pressure regulating balloon and urethral cuff size), when the device was placed or last revised, and whether the patient had previous urethral surgery for urethral stricture disease or pelvic radiotherapy.

Intraoperatively, surgeons should be aware that proximal corporal dilation can be challenging due to the presence of the urethral cuff and there is often a “step-off” that must be overcome gently to reach the ischiopubic rami [17]. Surgeons should also be mindful of the location of sphincter tubing and components. The control pump should be placed towards the midline but away from the AUS pump to avoid patient confusion. Post-operatively, we leave the sphincter deactivated for at least one week after implantation. Scrotal edema usually prevents simplistic use of the AUS pump and we postulate that leaving the AUS deactivated allows the urethra to recover from penile prosthesis implantation. After one month, we perform urethroscopy to evaluate the cuff site for signs of vascular compromise, such as bruising and irritation, in patients with urethral risk factors such as previous exposure to pelvic radiotherapy.

49.2.7 AUS Placement After IPP Placement

When patients present for consultation to repair both ED and urinary incontinence, we advocate AUS placement first. Nevertheless, there are some cases in which a patient is referred for AUS placement after a penile prosthesis has been implanted. In these patients, careful assessment of the penile prosthesis including component location and surgical approach is required to anticipate any challenges during AUS placement. Cross sectional imaging can be performed to identify reservoir location. We strongly advocate that AUS cuff placement proceed through a perineal incision so that it can be placed on a more robust part of the bulbar urethra. As discussed earlier, the presence of corporal cylinders can complicate urethral mobilization and

one must be keenly aware of this so as to avoid urethral injury. When a transcorporal approach is pursued, surgeons should also be aware that the corporal cylinder can be exposed and potentially damaged during initial urethral dissection. Post-operatively, activation of the AUS is dependent on the patient's oncological history with non-radiated patients routinely returning for activation in 6 weeks and those treated with radiation or urethroplasty returning in 10–12 weeks.

When considering revising an AUS to treat persistent incontinence, clinicians must be aware that this can easily push a patient towards erosion. As such, AUS revision should only be offered to healthy patients, such as those without cardiovascular disease, diabetes mellitus, or history of pelvic radiation or urethroplasty, and who present with significant incontinence or mechanical failure.

By adhering to conscientious pre-operative protocol and assessment, intraoperative technique, and diligent post-operative follow-up, patients that undergo staged device implantation can be richly rewarded with dramatic improvements in sexual and urinary function. Nevertheless, patients should be warned pre-operatively and followed closely for the appearance of device-related complications which will be discussed in subsequent sections.

49.2.8 Device-related Complications

Dual prosthetic implantation placed either in a staged or synchronous fashion may compound the risk of device-related complications. It is important to discuss infectious, erosive, and mechanical failure related complications so that patients can be appropriately selected and counselled.

49.2.8.1 Urethral Complications

The most devastating complication that may be heightened with dual prosthetic implantation is urethral erosion. Sundaram et al. found that after long-term follow-up, patients with both an IPP and AUS had a statistically significant higher rate of AUS erosive complications (11.6%) compared to patients with only an AUS (4.3%) during the

same study period [18]. This also translated to a markedly increased rate of explantation in the combined prosthetic group compared to patients with solely an AUS (17% versus 9.2%, $p = 0.44$). They hypothesized that the combination of prosthetic cylinders and the urethral cuff negatively affects urethral vascularity due to bidirectional extrinsic compression and impaired corporal blood flow. A similar observation was described by Mock et al. who found that history of an inflatable penile prosthesis was associated with higher device explantation rate in patients who undergo transcorporal cuff placement [19]. While these patients were already high risk due to the need to undergo transcorporal placement it nevertheless shows the impact of the penile prosthesis on urethral vascularity and integrity. It is also worth mentioning the erosion rates in the previously discussed studies including Kendirci's multicenter analysis which showed that 2 of 22 (11%) patients experienced urethral erosion [4]. In their series of 32 patients, Martínez-Salamanca et al. reported that 2 (6.2%) patients experienced a urethral erosion [10]. An AUS-only cohort of patients was not available for comparative analysis in these last studies. While the above studies suggest that erosion is a risk with both devices in place, a recent statewide analysis of patients found no increased risk of AUS revision or removal surgery in patients with both implants compared to patients with only an AUS [20].

Nevertheless, while there may be debate over the actual risk of erosion, we strongly believe that urethral vascularity is impacted by penile implant cylinders and patients considering both implants should be counselled on the potential for erosion. Patients with urethral risk factors such as prior urethroplasty and treatment with pelvic radiotherapy should be carefully evaluated prior to implantation, allowed to recover from the first surgery for at least 6 months, and followed closely thereafter. In our view, these at-risk patients are not candidates for synchronous implantation.

49.2.8.2 Infectious Complications

By adhering to strict surgical site infection prevention protocols and use of antibiotic-impregnated

materials, the risk of device infection should be no greater in patients with both devices than in those with just a single device. The risk of spread to the other device should be mitigated if staged implantation is performed. If combined implantation is chosen, the available literature suggests that there is no increased risk of infection.

49.2.8.3 Mechanical Failure

While the available studies on dual device implantation lacks sufficient power, follow-up duration, and comparative groups to confirm that there is no increased risk of mechanical failure, they suggest that the presence of both devices does not make them more susceptible to failure. To clarify this uncertainty, Patel et al. used a statewide database of patients who underwent IPP placement, AUS placement, or placement of both devices, to examine contemporary outcomes of patients with both devices. They found that patients with both devices experienced statistically significant higher rates of IPP reoperation (16.0% versus 8.9%, $p < 0.01$) and explantation (8.3% versus 3.1%, $p < 0.01$) compared to patients who only had the IPP, after both one year and three years of follow-up [20]. No differences were seen in AUS outcomes between patients who had an AUS only and those with both devices. While the results of this study are significant, it was unable to specify the indications for prosthetic revision or removal surgery. Nevertheless, patients should be made aware that revision surgery is sometimes required after implantation.

49.2.9 Special Considerations

49.2.9.1 Dual Implantation After Radical Cystectomy and Neobladder Urinary Diversion

Coexistent ED and SUI is not a phenomenon limited to patients after prostatectomy. It is also a common sequela that negatively affects patients that have undergone radical cystoprostatectomy and orthotopic neobladder urinary diversion for treatment of urothelial carcinoma. While several studies have shown that dual device implanta-

tion is safe and effective in patients after radical prostatectomy, there are no series describing the outcomes of dual device implantation in this complex patient population. Due to the presence of urinary diversion, history of major lymphadenectomy, and bowel anastomosis, there is theoretically an increased potential for intraoperative and long-term reservoir related complications. Despite these challenges, Loh-Doyle et al. reviewed their institutional experience and found no increased risk of device-related complications after long-term follow-up in either the IPP and AUS [15]. Due to the increased importance of bladder cancer survivorship, dual prosthetic reconstruction should be offered when indicated.

49.3 Male Urethral Sling and Penile Implant Surgery

Recently, as an alternative to concomitant implantation of artificial urinary sphincter and an inflatable penile prosthesis, some patients and their surgeons may choose a male sling and an inflatable penile prosthesis for various reasons, such as less invasiveness of the male sling surgery, cognition problems, deficient hand dexterity, unwillingness to mechanically operate an AUS device during voiding, and cost of the AUS (Fig. 49.2).

49.3.1 Patient Selection

After failure of conservative management, most patients are assessed for ED and SUI, either independently, or jointly by available experts depending on institutional referral patterns. The diagnostic evaluation protocol should be directed to each of these problems separately and should be identical to the one undertaken if combined placement of an AUS and IPP is considered. Because such evaluation is described in other chapters of this textbook, only some specific details will be discussed here to avoid redundancy. It is critical to exclude radiotherapy or multimodal therapy regimens that include radiation as they remain contraindications to MUS surgery. The etiology of incontinence, duration of dam-

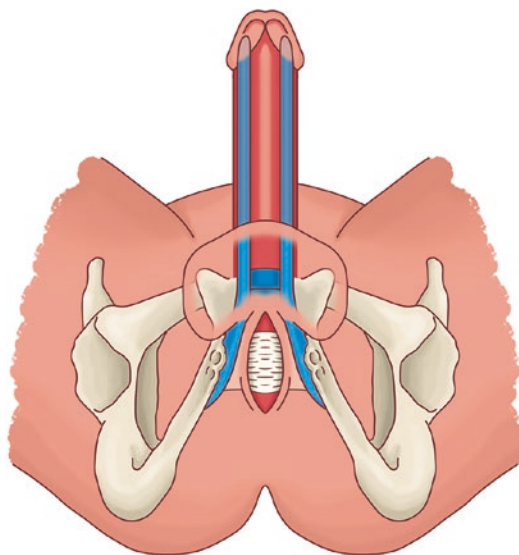


Fig. 49.2 Perineal perspective of dual implantation of male suburethral sling and penile prosthesis devices

age inflicted, prior treatments, prior abdominal or genitourinary surgery, and medical comorbidities should be included in a thorough pre-operative assessment. Diagnostic evaluation of ED follow a schema as set forth by the recently published American Urologic Association Guidelines on Erectile Dysfunction and should include determination of neurovascular risk factors, such as diabetes mellitus, hyperlipidemia, smoking, obesity that may also impact device outcomes.

While the AUS remains the standard treatment for male non-neurogenic stress urinary incontinence, especially following prostatectomy or cystoprostatectomy, male slings provide an alternative treatment for patients with mild to moderate stress urinary incontinence resulting from injury to the sphincteric mechanism, and in the absence of prior radiotherapy. Quantification of incontinence severity with pad count and validated questionnaires for voiding and sexual functions should be performed. Urodynamic testing should also be implemented to assess bladder function parameters such as capacity, compliance, stability and sphincter (in)competence. Efficient detrusor contractility must be maintained to overcome fixed urethral sling resistance.

The choice between an AUS and a MUS for male stress urinary incontinence is a complex

Table 49.3 Male urethral slings: indications and benefits

<i>Patient-specific indications</i>
Does not want or cannot use a mechanical device
Mild-moderate incontinence
Adequate residual sphincter function
Capable of generating strong detrusor contraction (to overcome fixed sling resistance)
No prior treatment with pelvic radiotherapy
<i>Advantages of sling surgery</i>
No post-operative healing period prior to device activation
No need to manipulate device
Achievement of instantaneous significant improvement in continence
No circumferential occlusion pressure
Low risk of urethral atrophy/erosion
Male slings are diverse but adjustability is a new concept

process. SUI severity is subjective and mostly dependent on a patient’s self-perceived bother and quantification of wetness, which may not always reflect accurately severity of incontinence [21]. Even if the clinical parameters indicate the use of an AUS device as a more reasonable option, patient choice may dictate otherwise, and this may be related to the invasiveness of surgery, mechanical device specificities or risk of other treatment adverse features [22]. In general terms, benefits of a MUS include: (1) no post-operative healing period prior to device activation; (2) no need to manipulate the device; (3) achievement of instantaneous improvement in continence; (4) no circumferential occlusion pressure; (5) low risk of urethral atrophy/erosion; (6) male sling diversity with *adjustability* being reported as a new and attractive concept (Table 49.3) [23].

49.3.2 Preoperative Preparation and Surgical Site Infection Prevention

Similar protocols mentioned above designed to prevent surgical site infection and used for AUS surgery should be implemented prior to prosthetic implantation, including screening for MRSA colonization and treatment with intranasal mupirocin

whenever indicated. On the day of surgery, hair is clipped and alcohol-based skin preparation and scrub of the surgical field is performed before incision. Broad spectrum intravenous antibiotics are routinely administered for infection prophylaxis when multicomponent prosthetics are implanted.

49.3.3 Timing of Device Placement

After electing to undergo male urethral sling and penile prosthetic reconstruction, a decision must be made whether to implant both devices concomitantly during the same single surgical session or in a staged manner. To date, there is a paucity of literature on outcomes for the treatment of ED and male SUI with combined IPP and MUS surgery and most are single institution case series [24]. Since 2005, a few reports have been published on the success and safety of synchronous placement of the male sling and inflatable penile prosthesis, using either a single perineal incision or more than one incision, to avoid two separate anesthetic events. Both of these approaches have demonstrated high satisfaction without any increased risks of complications [25–27]. Nonetheless, despite its feasibility and advantages, including associated cost and time savings, synchronous device implantation has not gained quick popularity among implanting urologists. This apprehension is multifactorial and is perhaps due to presumptions of increased risk of surgical complications as well as the reduction in insurance reimbursement for synchronous device placement. For synchronous implantation, the penile prosthesis can be placed ahead of the sling or vice versa based on the surgeon’s personal preference [28]. If a staged approach is selected, the sling should be placed first to avoid penile prosthesis contamination with urine. Nevertheless, timing continues to be a debated topic and worthy of in-depth debate.

49.3.4 Surgical Technique

All dual penile prosthesis/synthetic male sling implantations require meticulous atten-

tion to detail to minimize the risk of infection and maximize success and patient satisfaction. Preoperative sterile urine cultures and good skin integrity should be ensured. Broad-spectrum intravenous antibiotics are administered approximately 1 h before the procedure. Under general anesthesia, the patient is positioned in the social lithotomy position. In our institutions, we do not think an exaggerated lithotomy position is either critical or necessary. A 14 or 16 Fr Foley catheter is placed to drain the bladder and is left indwelling for 24 h. Copious antibiotic irrigating solution is used to wash the surgical field throughout the entire procedure. We prefer to implant the sling first followed by the IPP to save the penile prosthesis in case of inadvertent urethral injury and abortion of the surgery.

A single or two-incision techniques can be used for placement of the MUS and IPP, depending on surgeon's training and preference. A single incision technique apparently seems to be more advantageous. Although a single transverse transscrotal (a modification of the penoscrotal approach) incision has been described for concomitant AUS and IPP implantation, to our knowledge it has not been used for MUS and IPP in the same setting [3, 10]. In our centers, a 5-cm midline perineal incision is routinely made, and dissection is carried to the bulbospongiosus muscle, which is split in the midline and the central tendon is detached partially off the bulbar urethra proximally. Depending on the type of male sling (e.g., AdVance, Virtue Quadratic, ATOMS, etc), a tunneler with the suture is passed on the either side and rotated onto the surgeon's fingertip towards the incision. The sling material is passed through this track. The same maneuver is repeated on the opposite side. The sling is oriented and adjusted to its final position elevating and/or compressing the urethra.

IPP implantation proceeds preferentially through a penoscrotal incision with the dissection of the perineal-scrotal fat until both corpora cavernosa are exposed. Buck's fascia is incised bilaterally. Four 2-0 Monocryl or PDS stay sutures are placed in each corpus cavernosum. An approximately 2-cm vertical corporotomy is made in between these two rows of pre-placed

sutures. Proximal and distal dilatation followed by corporal measurements are carried out in the routine fashion. The corresponding cylinders are inserted, and the pre-placed sutures are tied to close the corporotomies. The Transversalis fascia at either right or left inguinal ring is approached through the same perineal incision, posterior to the scrotal contents and pierced inferior and medial to the spermatic cord with Metzenbaum scissors. It is important to perform this maneuver with an empty bladder to avoid its inadvertent perforation. A pouch anterior and lateral to the bladder in the Retzius space is created bluntly to lodge the reservoir with the aid of a baby Deaver retractor. Tubes are connected in the standard fashion using quick connectors. The pump is placed in the dependent dartos pouch of the scrotum right above the perineal incision, using a purse string suture to secure the pump in the dartos pouch. The surgical wound is closed in layers in the usual fashion. The urethral catheter is removed on the following day before patient discharge. The cylinders are kept partially inflated for about 2 weeks. Patients are instructed to start using the IPP 4–6 weeks after hospital discharge.

49.3.5 MUS Placement After IPP Placement and Vice Versa

There are three types of male urethral slings: (1) the bone-anchored slings (compressive effect), which have fallen out of use; (2) the transobturator slings (both compressive and repositioning effects); and (3) adjustable sling system. Ongoing research and development have led to gradual evolution of sling products with better design with, improved efficacy, and less morbidity.

The literature on the chronological sequence of device implantation is limited/almost nonexistent. Two distinct settings should be considered: (1) dual synchronous prosthetic device implantation or (2) sequential surgery performed in two separate settings. In either case, the authors advocate placement of the MUS first to reduce risk of urine contamination of the surgical field. However, if a patient is referred for MUS placement after a penile prosthesis has been implanted,

careful assessment of the penile prosthesis including component location and surgical approach is required to anticipate any challenges during MUS placement. We strongly advocate a preoperative pelvic and perineal CT scan to assess exact location of the IPP components and trajectory of the tubing. One must also be keenly aware of the risk of urethral injury or corporal perforation during tunneller passage and, therefore, should exercise extreme caution. Otherwise, the procedure is generally straightforward. Conversely, if a MUS has been implanted first, we recommend placement of the IPP through a penoscrotal, or even better, an infrapubic approach with caution during corporal dilatation to avoid perforation of the crural part of the corpora cavernosa.

49.3.6 Clinical Outcomes

Overall success rates vary from 54% to 80% with low complication rates [29–32]. Adverse prognostic factors for failure and complications were identified in one study, specifically prior radiotherapy, pad weight >200 gm/24 h and history of interval stricture before MUS implantation [33]. For dual implantation, satisfaction rates have ranged from 89% to 100% for sexual function and from 65% to 100% for continence [25, 29, 34, 35].

49.3.7 Device-related Complications

Identical to AUS and IPP dual implantation, the potential for infectious and mechanical complications exists and, as such, careful patient selection and counselling is of paramount importance. Reports of MUS-related complications are based on series in which only a sling was placed and these complications vary with MUS type.

49.3.7.1 Non-mechanical Complications

Again, the literature is scarce regarding complications following dual prosthetic implantation. No study has reported urethral complications in this setting. Overall complications associated

with MUS surgery range from 15.3% to 23.9%, including wound infection, device infection, pain, urethral injury, and urinary retention [36, 37]. MUS MS is not a circumferential occluding device; therefore, the risk of urethral atrophy and erosion is low when compared to the AUS [22].

Major postoperative complications include transient urinary retention requiring temporary re-catheterization, local wound infection, perineal pain and inner thigh sensory numbness. As discussed in previous chapters, MUS explantation rates have been reported from 3.2% to 20% [37, 38].

49.3.7.2 Mechanical Complications

The mechanical complications associated with IPP have been reported extensively. The rate of these complications does not appear to be different in dual male sling and penile implant surgery since the same patient-related and surgical circumstances apply. Due to its inherent non-mechanical nature, there are no mechanical complications related to MUS.

49.4 Conclusions

In carefully selected patients, penile implant and continence procedures can be performed safely, either synchronously or in a staged manner. Due to the prevalence of coexistent refractory ED and SUI after treatment for lower urinary tract malignancy patients, dual device placement should be considered a fundamental component of restoring quality-of-life in many patients. While the results of synchronous and staged implantation are both promising, more robust long-term comparative studies are needed to demonstrate the durability of device outcomes in these specific cohorts. For patients with milder degrees of incontinence and no contraindications, a MUS can be offered as an alternative to the AUS based on their safety and ability to control continence and can be placed in combination with an IPP. Due to the complexity of concurrently treating coexistent and refractory ED and SUI, patients should be referred to large-volume institutions with a comprehensive prosthetic urology subspecialty unit.

Key Summary Points

- Coexistent erectile dysfunction (ED) and stress urinary incontinence (SUI) are common in many patients after treatment for lower urinary tract urologic malignancy.
- After failure of conservative treatments, dual prosthetic implantation, both synchronously or in a staged manner, is an excellent, safe, efficient and cosmetic treatment solution – minimizing risk and maximizing patient satisfaction – and should be offered to patients who desire restoration of urinary and erectile function and return to their quality-of-life.
- Due to the technical feasibility and safety of dual device placement, some prominent implanters support synchronous placement using a single scrotal incision and to avoid two separate anesthetic events. A two, separate incision (perineal plus infrapubic or penoscrotal) technique is favored by others with similar outcomes. The risk for surgical and mechanical problems is not increased.
- Single-stage dual implantation significantly reduces operative times and cost compared to the sum of individual implant procedures without an increased risk of prosthetic infection or erosion. While two separate anesthetic events are required, staged implantation is still the approach favored by most high-volume implanters in the United States and Europe.
- Timing and sequence of device implantation is dependent on what is most bothersome to the patient. In the authors' experience, patients with coexistent ED and SUI are typically bothered most by urine leakage and usually seek to correct this first.
- The choice of a MUS over an AUS with IPP for dual implantation depends on lesser severity of SUI and absence of radiotherapy, and on other reasons, such as less invasiveness of the male sling surgery, cognition problems, deficient

hand dexterity, and unwillingness to mechanically operate an AUS device during voiding, as well as cost and availability of the AUS.

- Due to the complexity of synchronous dual prosthetic implantation surgery, patients should preferably be referred to large-volume institutions with a comprehensive prosthetic urology subspecialty unit for better outcomes.
- Urologic surgeons and their patients will increasingly favor dual implantation.

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Vascular (Arterial and Venous) Surgery for Erectile Dysfunction

50

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50.1 Introduction

Male erectile function results from a seamless interplay between vascular, psychological, endocrinologic, pharmacologic, metabolic, neurologic factors and sinusoidal health. Erectile dysfunction (ED) is defined as the inability to attain or maintain a rigid penile erection for satisfactory coitus [1]. ED is a common disorder worldwide, plaguing a surprisingly high percentage of men; it has troubled humans for millennia and demands more research and better treatment options. Unfortunately, the issue persists, even after the introduction, in 1998, of phosphodiesterase 5 (PDE-5) inhibitors, which were heralded as a panacea for ED and have become the first-line drugs for treating the dysfunction [2]. Until recently, the vast majority of ED cases were thought to be psychogenic in nature. In reality, exclusively psycho-

genic causes account for approximately 40% of ED cases [3]; in most patients, ED is in fact etiologically organic, particularly on a vasculogenic basis [4]. Although ED can stem from a number of causes – including cavernosal fibrosis, chronic systemic diseases, endocrinologic imbalance, drug's adverse effects, neurologic deficits, psychological illness, and vascular disorders – in this chapter our major interest is in the latter category, which can be further divided into arteriogenic ED, venogenic ED, and a “mixed type” ED. Subsequently, we will concentrate on penile arterial revascularization and venous surgery, performed with the aims of re-establishing blood supply and blocking venous drainage of the corpora cavernosa (CC), respectively.

50.2 Advanced Penile Anatomy and Erection Physiology

Updated penile anatomy. It is commonly understood that a functional heart is indispensable to each vital organ; penile erectile function is no exception in this regard. The human penis's extraordinary erectile capability depends on the sinusoids, which are independently distributed throughout the corpora cavernosa (CC), glans penis, and corpus spongiosum. The human penile anatomy has been in its current form for hundreds of thousands of years [5] and has been closely studied for many centuries; despite that,

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penile anatomy and erection physiology were not well understood. For example, it was conventionally understood that a single uniform tunica layer encircles the CC and that a single deep dorsal vein (DDV), flanked by two dorsal arteries, is positioned between the tunica albuginea and Buck's fascia, which is further encircled by Colles' fascia, dermis, and the skin layer [6]. We may question how the veno-occlusive mechanism operates if no outer tunical layer exists to counteract escalating intra-cavernosal pressure; moreover, are penile reconstructive strategies derived from conventional understanding anatomy and erection physiology going to be effective?

Our studies corroborate a fibro-skeleton model of the tunica albuginea of the CC as a bi-layered structure with a 360° complete inner circular layer and a 300° incomplete outer longitudinal coat spanning from the ischiocavernosus and bulbospongiosus proximally and extending continuously into the distal ligament of the glans penis, which caps the corpus spongiosum [7]. The above two muscles, outer tunica layer and the distal ligament could be collectively categorized as skeletal components. The inner layer, intracavernous pillars and cavernosal membrane contain and support the cavernosal sinusoids; these, along with the erection-related vasculature, could be collectively categorized as the smooth muscle components [8]. When a man has an erection, the CC is transiting from a soft state to a bony and rigid state, which results from escalating arterial supply rate – from 2–3 ml/min to 60–80 ml/min [9]. In addition, our comparative penile anatomy study on mammalian species disclosed that the outer longitudinal tunica will group to form a distal ligament – an analog to the os penis present in quadrupeds such as dogs and rats [10]. Without this os analog, the entire penis could not bear the buckling pressure applied during coitus, nor could it do so during ejaculation. Furthermore, an integral glans protects the reflexogenic erectile mechanism that may be evoked in response to global contraction of the perineal muscles, which in turn compresses the veins and erectile tissue to encourage penile rigidity and enable rhythmic ejaculation.

This fibro-skeleton interacts with erection-related vasculatures, whose distinct design provides a milieu – unique within the human body – for applying Pascal's law, which states that pressure applied to any portion of the enclosed fluid at rest is transmitted undiminished to every part of the fluid and to the wall of the containing vessels [11]. This peculiar design results from the outer longitudinal layer acting as the wall, assuming there is no corporal-veno-occlusive dysfunction. This implies that the sinusoidal and outer tunica are key structures in erection physiology. Overall, a healthy erectile function requires a similarly healthy erection-related vascular system.

The major arterial supplier of the CC is the internal pudendal artery, which is the final branch of the internal iliac artery, although accessory contributions may come from the obturator, vesical, femoral, and external iliac arteries [12]. Exiting the pudendal canal, the internal pudendal artery branches off to the bulbourethral, cavernosal and dorsal arteries. The CC sinusoids are primarily supplied by the cavernosal artery and secondarily by the dorsal artery (Fig. 50.1). There are two types of branches originating from the cavernosal artery [13]. Firstly, the outer capillaries – which are also responsible for supplying nutrition to the sinusoidal tissues – chiefly serve the smooth muscle component, skeletal component, nerve fibers, and vasculature itself. Secondly, and for conducting erectile function without the necessity of entering capillaries, the inner helicine arteries open directly into cavernous spaces – which provide ample room for pooling blood – and are then emptied into the post-cavernous venules. In a man with normal erectile function, multiple layers of smooth muscle surround the helicine branches. This muscle is contracted while the penis is flaccid, allowing only small amounts of blood into the lacunar spaces. After the appropriate stimulus, muscle relaxation occurs and the arteries dilate and straighten, increasing blood flow and dilating the lacunar spaces, in turn applying pressure against the outer longitudinal layer of the tunica albuginea to reduce blood drainage, which eventually results in a rigid erection. This is the crux of penile veno-occlusive function.

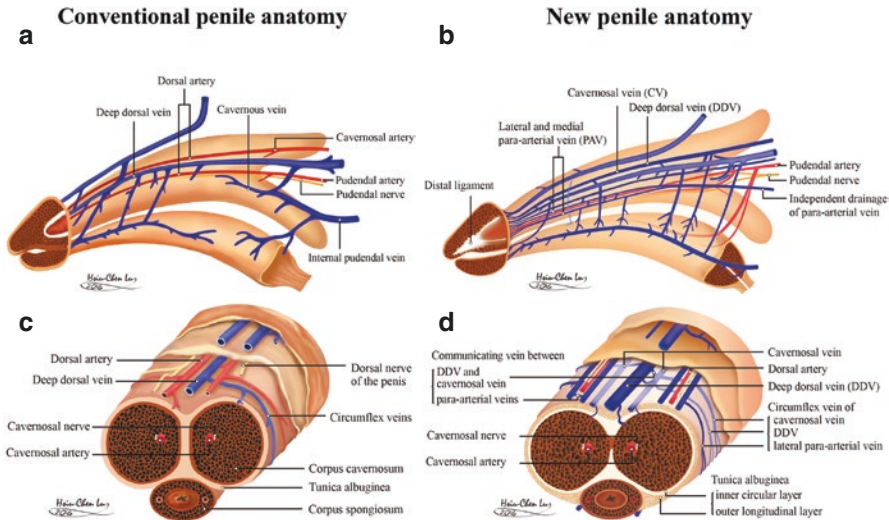


Fig. 50.1 Illustrations of traditional and new penile venous anatomy. Traditional penile venous anatomy (left): **(a)** Lateral view: The glans penis is exclusively composed of uniform sinusoids only, and the deep dorsal vein (DDV) is sandwiched by a pair of dorsal arteries (DA). The ratio of arteries to veins remains identical to that of the umbilicus vessel, which is 2:1. **(b)** Cross-section of the pendulous portion of the human penis. The tunica albuginea of the corpora cavernosa is consistently described as a single-layered coat with uniform thickness. The median septum is complete. A single DDV and two DAs are present between the tunica albuginea and Buck's fascia. New penile venous anatomy (right): **(a')** Lateral view: The glans penis is composed of specific sinusoids and a stout distal ligament – the os penis analog – for supporting the entire glans. The DDV is consistently in the median position and receives the blood of the emissary veins from the corpora cavernosa and of the circumflex vein from the

corpus spongiosum. The DDV is sandwiched between the cavernosal veins (CV), but these lie at a deeper position. Bilaterally, each DA is sandwiched by its corresponding medial and lateral para-arterial veins (PAVs). Note that the lateral PAV merges with the medial vein proximally. The deeper color of the veins indicates the deepest part of the vasculature. **(b')** Cross-section of the mid-penis: Note that there are seven veins (not one vein as traditionally depicted), although the count is reduced to four at the level of the penile hilum because each pair of the veins merge. Erection-related veins are arrayed in an imaginary arc on the dorsal aspect of the tunica albuginea, which is composed of multiple collagen bundles with a 360° complete inner circular layer and a 300° incomplete outer longitudinal coat. Thus, the penile vascular system still complies with the general rule in the body that the number of veins is greater than the number of arteries

The sinusoidal blood drains directly to the sub-tunical venous plexus, subsequently passing through the tunica albuginea to the emissary veins in an oblique route, and then to the deep dorsal vein (DDV), cavernosal veins (CVs) and para-arterial veins (PAVs) separately. DDV, CVs, and PAVs are collectively called erection-related veins (ERVs) because they drain the sinusoidal blood independently [14]. Thus DDV, CVs and PAVs are associated with their own specific emissary veins. This new understanding of penile venous anatomy is highly significant. Not only do we consider the traditional DDV significant, but also the CVs – which are distributed throughout the entire length of the penis – and the para-arterial veins. The DDV lies consistently in the

median position and receives blood from the circumflex veins of the corpus spongiosum and from the emissary veins of the corpora cavernosa. Emissary veins run between the inner and outer layers of the tunica for a short distance, often piercing the outer layer bundles in an oblique manner. Therefore, and significantly, these emissary veins can be easily occluded by the shearing action elicited by the inner circular and outer longitudinal layers of the tunica albuginea.

Overall, the DDV is sandwiched by cavernosal veins that coalesce to a singular vein at the penile base. Bilaterally, each dorsal artery is sandwiched by the medial and lateral para-arterial veins, respectively. Veins from the glans penis form a retrocoronal plexus that drains predomi-

nantly into the DDV, the urethral veins, and the corpus spongiosum. The deep dorsal vein courses proximally in the midline between the two corpora cavernosa and empties into the periprostatic plexus. The superficial dorsal vein drains the skin and the subcutaneous tissue superficial to Buck's fascia and may have direct shunts to the corpora cavernosa. This, in turn, drains into the superficial external pudendal vein and is frequently seen in young males with ED. If the erectile function of the corpora cavernosa is healthy, the penis, appropriately stimulated, expands not only in its girth but also in its length.

Apagogical erection physiology. ED can be the consequence of a number of contributors: psychological disturbance, hormonal imbalance, vascular insufficiency, neurological deficit, sinusoidal fibrosis, adverse pharmacological effect, and metabolic disease. This may not be surprising, given the complexity of erection physiology: ideal erectile function is a seamless interplay between an intact central nervous system and a functional penis. However, such varied etiologies beg the question of which causes are most to blame. Given the dramatic effects demonstrated by phosphodiesterase-5 -inhibitors (PDE5 $\downarrow$) in treating erectile dysfunction – with 81% of oral Sildenafil users experience improved erections, and 63% successfully engaging in coitus – there is unsurprisingly a bias towards blaming the endothelial function. However, a rapid attenuating response to Sildenafil indicates that escalating drainage veins are in fact primarily responsible for ED. An apagogical hemodynamic study on fresh and defrosted cadavers, conducted between 2002 and 2013, further supports this hypothesis: in the study, rigid erections were unexceptionally reproducible despite the fact that, in human cadavers, the corporeal sinusoids lack endothelial activity [15]. Constant low-pressure perfusion was used to mimic arterial inflow, and the staged removal of erection-related veins (ERVs) produced increasingly rigid erections, attesting to the pivotal role that penile veins play in erection physiology. In fact, it is no exaggeration to say that, at its core, an erection is just a mechanical phenomenon; therefore, in the list of ED contributors, the penile venous aspect has no equal.

Inferentially, the use of penile venous surgery to treat ED is well worth exploring [16]. This is particularly true in light of our improved understanding of the penile vasculature, the study of which was inspired by past failures of venous removal; these surgeries were incomplete because they were based on an incomplete understanding of penile anatomy, in which only a single deep dorsal vein (DDV) was considered.

The psychogenic factor would be ranked second in the list of contributors because, in clinical experiments of oral tadalafil, the placebo effect accounts for 42.8% of reported improvement [3]. It may be challenging, and perhaps impossible, to curtail the psychogenic influence in studying or treating men with ED. However, this chapter focuses on the penile physiology. The rigid erection of the corpora cavernosa depends overall on cooperation among healthy sinusoids, an intact normal tunica, functional arteries, and competent veins; if the latter two are marked by dysfunction, they require penile arterial and venous reconstructive surgeries, respectively.

50.3 Penile Artery Reconstructive Surgery for Arterial Insufficiency

In general, the risk of arteriogenic ED increases with age; unsurprisingly, it is most prevalent in those with arterial disease risk factors such as obesity, diabetes, hypertension, cigarette smoking, and hyperlipidemia [17]. While older men are most susceptible, it can occur in men of any age due to pelvic trauma, straddle injury, long-time bicycling, or other activities that damage penile tissue such as “jelqing” (a movement performed with the intention of increasing penis size and which involves vigorous squeezing of the penile shaft) [18]. It is commonly agreed that accurate diagnosis of arterial insufficiency can be made via color Doppler ultrasonography; a diagnosis of penile arterial disease is made if peak systolic velocity is less than 25 cm/s or – less invasively – either a prostaglandin E1 test or papaverine intra-corporeal injection test fails to produce a rigid erection [19]. Angiography, the

benchmark for final investigations into arterial insufficiency, is reserved for those males who are considering treating their ED through penile arterial reconstructive surgery, concurrent angioplasty, or embolization for treatment of arterial insufficiency or veno-occlusive dysfunction [20].

Penile artery reconstructive surgery. In 1973, Michal first published an article on penile arterial reconstruction done in an effort to enhance arterial flow to the corpora cavernosa of a man suffering from ED [21]. He administered revascularization surgery by an anastomosis of the inferior epigastric artery (IEA) to the corpora cavernosa. Subsequently, deep dorsal vein arterIALIZATIONS, either with extensive ligation of the circumflex veins or without venous ligation, were introduced by Virag and Haudi in 1981 and 1986, respectively [22, 23]. Varied modifications were undertaken for achieving more favorable outcomes, such as the Furlow-Fisher procedure,

in which IEA is made in an end-to-side anastomosis to the DDV while multiple ligations are performed at the lateral circumflex veins, distal DDV, and proximal DDV (Fig. 50.2) [24]. The procedure aims to increase penile arterial inflow and limit the venous drainage in one operation. Post-operative end outcomes of arterial revascularization surgery have been mixed – both because varied surgical techniques and surgical instruments have been employed and because patient selection standards have been minimal to non-existent [25, 26]. In general, surgical treatments were deemed limited in merit and without long-term benefits (Table 50.1). Furthermore, complications historically occur in about 25% of patients who undergo penile revascularization surgery [27]. Immediate post-operative arterial hemorrhage may result from disruption of the microvascular anastomosis with hematoma formation. The potential risks of these techniques,

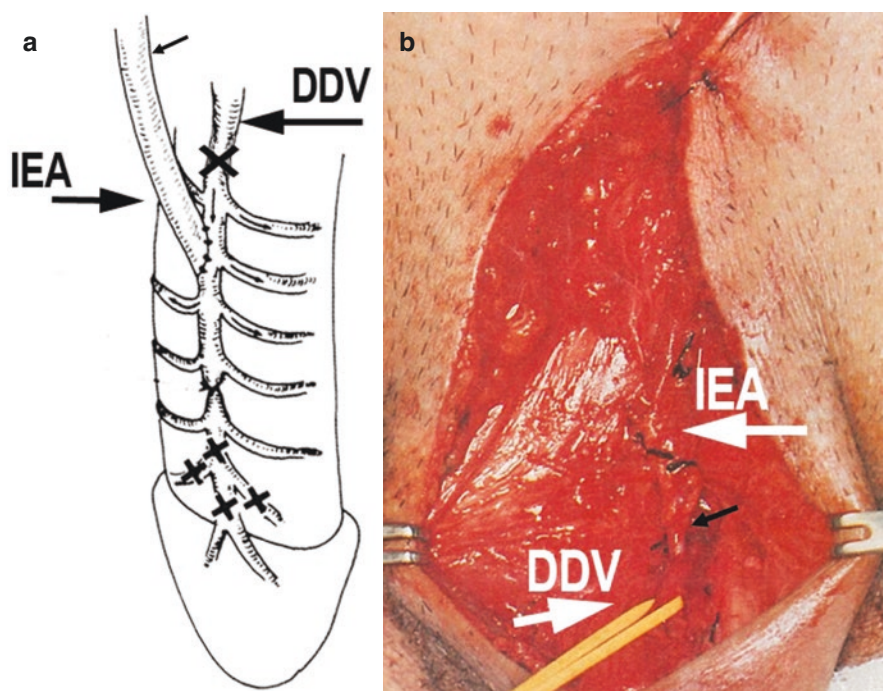


Fig. 50.2 Illustration and photo of one strategy for penile arterial reconstructive surgery. (a) Illustration of the Furlow-Fisher procedure. The inferior epigastric artery (IEA) is well-prepared and its direction shifted from cranially to caudally for end-to-side anastomosis with the deep dorsal vein (DDV). The DDV has been ligated dis-

tally and proximally; the same goes for those circumflex veins as laterally as physically possible (not shown); meanwhile, the valve structures are ruptured within the DDV. (b) Photo of an existing arterialization of DDV (yellow traction) with IEA (white arrow)

Table 50.1 Summary of representative publications on penile revascularization surgery in recent decades

Author/publication	Patient No/age (y)	Procedure	Follow-up (months)	Intercourse success rate
Jarow/1996	11	DDVAA ^a	50	92
Lukkarinen/1997	24	Hauri/F-F ^b	N/A ^c	77
Manning/1998	62	Virag/Hauri	41	54
Sarramon/1997	114	DDVAA	17	63
Kawanishi/2004	51	Hauri/F-F ^b	36–60	85.9
Vardi et al./2004	52/28.5	N/A ^c	70.8	
Kayigil et al./2008	43/59.7	F-F ^b	22.1	
Munarriz et al./2009	71/30.5		34.5	
Kayigil et al./2012	125/43.2	F-F ^b	73.2	63.6→92.8

^aDDVAA denotes deep dorsal vein arterialization and arterial reconstruction

^bF-F is an abbreviation of the Furlow-Fisher procedure

^cN/A stands for non-applicable

such as spongy necrosis and hyperesthesia of the glans, cannot be avoided. Additional complications, such as penile edema, wound infection, inguinal hernia formation, postoperative penile shortage, and decreased penile sensitivity cannot be avoided [28, 29]. The most common complications are priapism and glans hyperemia, the prevalence of which deter continued application of these surgeries [30]. Not surprisingly, most urological surgeons have regarded surgical treatment as experimental at best. Although it is not without controversy, penile arterial reconstructive surgery has been studied by several teams and its utility is supported in young men who have suffered from arterial trauma, and in older men with localized arterial occlusive disease, particularly in those patients without other arterial risk factors (Fig. 50.2). Endovascular angioplasty with or without stenting is also recommended as a minimally invasive option for this disease entity [31].

50.3.1 Angioplasty and Arterial Stent

The prevalence of arteriogenic ED increases in men over the age of 50. It can be due to atherosclerotic or traumatic arterial occlusive disease. Impaired penile perfusion may be among the first signs of ED and can herald coronary arterial disease (CAD). In fact, ED has been shown to be a bellwether for development of CAD in asymptomatic men [32]. Given the

success of endovascular drug-eluting stent (DES) placement for the treatment of CAD, [33] there have been many physicians interested in applying the same technology to the treatment of arteriogenic ED (Fig. 50.3a, b). However, there is currently no evidence of long-term benefits to treating men with arteriogenic ED with a minimally invasive DES. Further research is warranted.

50.4 Penile Venous Surgery for Patients with Erectile Dysfunction

Conventional penile venous ligation surgery. In 1873, the Italian physician Francesco Parona injected hypertonic saline into the dorsal penile vein of an impotent young man in order to reduce excessive venous drainage and thereby restore the patient’s erectile potency [34]. Although this might be the earliest form of sclerotherapy, neither succeeding publications nor contemporary works have resolved the paucity of favorable outcomes. The treatment method then shifted to penile venous surgery with venous ligation or resection of veins, done by Henry Raymond and James Duncan in 1895, Joe Wooten in 1902, and Frank Lydston – who reported on no less than 100 resections – in 1908 [35]. In the 1930s, Oswald Swinney Lowsley debuted a dorsal vein ligation enhanced with a perineal-crural plication of the bulbocavernosus and ischiocavernosus muscles with several

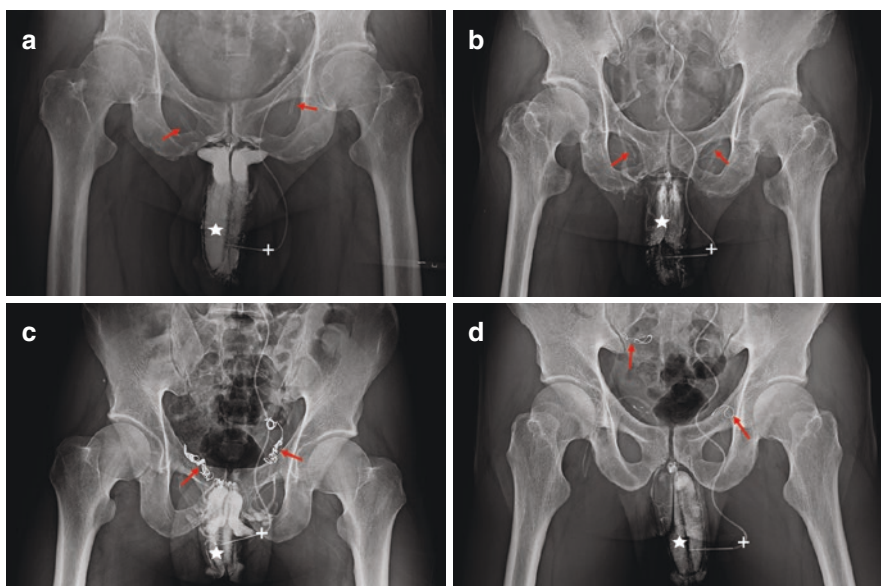


Fig. 50.3 X-ray imaging in patients who had elsewhere undergone endovascular interventions for treating vasculogenic impotence. **(a)** Depiction of one 57-year-old man who received an arterial stent (red arrows) but whose ED did not improve from it. This anterior-posterior view cavernosogram was obtained while a 10-ml diluted iohexol solution was intracavernously injected by a #19G scalp needle (white cross). Note the immediate filling of the corpora cavernosa (white asterisk) as well as the erection-related veins. Note as well the pudendal stents (arrowheads). **(b)** In a 68-year-old man, this anterior-posterior view imaging was obtained while a 15-ml diluted iohexol solution was intracorporeally injected by a #19G scalp needle (white cross). Note the immediate filling of the erection-related veins drained from the corpora cavernosa (white asterisk) and the pudendal

stents (red arrows) in the bilateral pudendal artery. **(c)** In this 24-year-old man who received coil embolization (red arrows) with sclerotherapy, this anterior-posterior view cavernosogram was obtained while a 10-ml diluted iohexol solution was intracavernously injected (white asterisk). Note the coils scattered both in the superficial dorsal veins (right) and internal pudendal vein (left). The erection-related veins are likely sclerotic and smaller. **(d)** In this 31-year-old man who underwent coil embolization with sclerotherapy to no benefit, this anterior-posterior view cavernosogram was obtained while a 10-ml diluted iohexol solution was intracavernously injected (white cross). Note the coils scattered both in the junction of right internal and external iliac vein (right arrow) and left internal pudendal vein (left arrow)

mattress sutures [36]. Penile venous surgery (PVS), however, was not popular until 1985 when Wespes stated that venous leakage is correctible [37]. At the time, it seemed that PVS could be a viable solution for treating ED and deserved attention given the cavernosography studies showing venous leak to be the primary cause of erectile dysfunction [38, 39]. The approach was expanded from ligation of a single deep dorsal vein to a more elaborate excision of the deep dorsal vein, and even the crural vein and cavernous vein, which drains the penile hilum. Still, the surgical blueprint was limited to a single deep dorsal vein system as depicted in the conventional penile anatomy (Fig. 50.1). As previously stated, the penile erection-related veins are so complex that a pair of cav-

ernosal veins and two pairs of para-arterial veins have been previously overlooked in the medical literature. Unsurprisingly, this incomplete understanding of the venous anatomy led to incomplete surgeries and therefore inadequate outcomes, and so the medical community concluded that there is insufficient evidence to support the routine use of PVS. A consensus of urologists agreed, despite a dearth of research into the issue, that the potential for venous recurrence meant any long-term benefits of PVS were minimal to non-existent. Most importantly, usage of electrocautery is a standard operating procedure among surgeons. Its use might be acceptable in any deconstructive surgery, even for brain tumors; however, it is not permissible in a functional reconstructive surgery on the

delicate corpora cavernosa, which is unique in the human anatomy for producing rigidity through intra-corporeal fluid retention. In our chronological practice as well as research, neither an electrocautery nor a suction apparatus is allowed at any point in the procedure [40]. A prerequisite for any PVS surgeon is the ability to limit the sinusoidal blood within the corpora cavernosa; otherwise, excessive bleeding will prevent the attending surgeon from proceeding further and will force the surgeon to apply electrocautery, thereby damaging the delicate penile tissues [41]. Therefore, *conventional* penile venous ligation deserves its condemnation and abandonment – not only for its lack of long-term benefits, but also for the unavoidable post-operative complications such as permanent numbness of the penis and irreversible deformity. [42]. The permanent numbness is a result of nerve damage, and penile deformity is plausibly a result of either fibro-skeleton alteration or loss of extensibility and sliding capability of layered tissues from electrocoagulation-induced fibrosis.

50.4.1 Important Consensus on Penile Vascular Surgery

Penile arterial reconstructive surgery is regarded as unproven and controversial. In 1996 [43], the AUA (American Urological Association) famously issued guidelines regarding penile venous and arterial surgery in men with arteriosclerotic disease, asserting that the surgery should be performed only in a research setting with long-term follow-up available. These guidelines were reiterated in the proceedings of the First Paris International Consultation on Erectile Dysfunction in 1999, again in the second such consultation in 2003, and yet again in the third such consultation in 2009. The AUA also reaffirmed their guidelines in 2005 with their issuance of *The Management of Erectile Dysfunction: An Update*. The ISSM's *Standard Practice in Sexual Medicine* textbook also agrees with this consensus. However, it may deserve reappraisal after a review of arterial reconstructions reported after 2004 (Table 50.1), including by Kawanishi and Vardi in

Table 50.2 Chronological refinement in penile venous stripping surgery methods since 1986

Methods	Patients				Presentation		Follow-up period (years)	Anatomy blueprint [Reference]
	No.	Age (Year)	Time period	Op. time (hours)	IR ^a (%)	SR ^a (%)		
Ligation	8	22–58	Jun. 1986 Aug. 1987	0.5–2.0	<50.0	0.0	5.0–17.0	Multiple ligation of single DDV ^a
Stripping	23	19–68	Sep. 1986 May 1987	2.0–5.0	80.0	52.5	5.0–32.0	Venous stripping as much as possible
Stripping	245	19–83	Jun. 1987 April 1991	2.2–3.1	67.8	NA	6.0–32.0	Venous stripping under local anesthesia since 1988
Stripping	1207	22–82	May 1992 Aug. 1997	2–3	69.7	57.6	8.0–32.0	Single DDV ^a with its branches
Stripping	615	23–83	Sep. 1997 July 2000	2–5	85.0	64.6	8.0–32.0	IIEF ^a available since 1998 Suspected penile venous anatomy
Stripping	378	19–81	Aug. 2000 Nov. 2003	2.1–5.0	90.4	76.6	5.1–8.2	<i>Sure penile venous anatomy</i>
Stripping	235	20–91	Jan. 2004 Jan. 2009	2.1–6.2	90.8	77.8		DDV ^a , CV ^a & PAV ^a
Stripping	103		Feb. 2009 Jan. 2011	4.2–8.0	88.7	68.7		Without well-trained assistant
Ultimate	283	20–75	Feb. 2011 Aug. 2016	2.1–7.5	95.7	85.3		Unpublished data, ultimate method of USPTO patent
Ultimate Assisted	132	19–85	Sep. 2016 Aug. 2018	2.5–6.5	96.8	87.3		Assisted with Acuvein
Total	3229	19–91	1986–2015	0.5–8.0	<50–95.8	0–87.3	0.2–32.5	

^aThe DDV, CV, PAV, IIEF, IR & SR are abbreviations for the deep dorsal vein, cavernosal veins, para-arterial veins, the international index of erectile function, improvement rate, and satisfaction rate, respectively

2004, Kayigil in 2008, Munarriz in 2009, and Kayigil in 2012 [44, 45]. Interestingly, researchers report without exception positive long-term outcomes when both penile arterial and venous reconstruction are incorporated; this implies that arterial reconstruction alone is not sufficient for long-term restoration of erectile function.

To isolate the vascular contribution to erectile function, apagogical hemodynamic studies were performed on both fresh and defrosted human male cadavers between 2001 and 2013. In each case, a rigid erection was categorically attainable – under very low infusion rate – following the removal of offending veins. This clearly has significant ramifications in relation to the vascular contribution and its role in treating ED patients. Although there are no comparative prospective randomized studies assessing the outcome of penile revascularization surgery for arteriogenic ED, based on the evidence in the literature, arterial reconstructive surgery may be offered to men younger than 55 who are non-smokers, non-diabetic, show no evidence of venous leakage, and demonstrate an isolated stenosis of the internal pudendal artery; young patients who have sustained focal arterial injury due to trauma are especially suitable.

Regarding penile venous surgery for patients with veno-occlusive dysfunction, although it is rejected by the larger medical community, in our practice – with its use of a method refined over three decades – the traditional complications of irreversible penile numbness and deformity have been virtually eliminated with the use of particular venous ligation techniques rather than electrocautery [46]. Penile vascular reconstructive surgery is viable if, and only if, the surgical handling is properly carried out using a sound method. We hope that it can be widely disseminated and practiced in the near future [47].

50.5 Chronological Development of Penile Venous Stripping

The advancements in penile anatomy and apagogical erection physiology, and in our surgical instruments and our surgical techniques, have underpinned the penile venous stripping surgeries

that, since 1986, we have performed on over 3000 men (Table 50.2). Neither a Bovie nor a suction apparatus is required for our penile venous stripping techniques, in which microsurgical ligation of each emissary vein is made closest to the outer tunica to block sinusoidal blood within the corpora cavernosa. In 1986 we introduced penile venous ligation of the proximal DDV in surgery performed on eight men suffering from ED. This simple procedure was first shifted to venous removal, and then later to venous stripping, although the surgery had, until 1999, been rooted in conventional knowledge of the venous anatomy, with its depiction of a single DDV. Within the past decade, the rate of successful coitus improved from 50% to 91%. This indicates that penile venous stripping is superior to venous ligation – which is plausible, given that only the former additionally treats the emissary veins.

50.6 De Novo Discovery of Penile Venous Anatomy

In reviewing medical history, it is uncommon to encounter a medical treatment that has sustained debate across 300 years, but such is the case for penile vascular intervention treating erectile dysfunction (ED). For the three centuries that penile venous surgery has been explored, its merit for use in treating ED has never been firmly established. As previously stated, the conventional PVS method has been condemned and abandoned; however, the efficacy of our penile venous stripping method is supported by the results in our large patient population. Our method has simply limited the venous outflow in the sinusoids, including in the corpora cavernosa, the glans penis, and the corpus spongiosum. (Unsurprisingly, some patients report, in addition to corporeal rigidity enhancement, a “bonus” of an enlarged glans.) In 1999, 35 patients received repeated cavernosography – because although their sexual function remained improved when compared to their pre-operative state, these patients still experienced a gradual decrease in erection quality which occurred in a period between six months and seven years post-operatively. Cavernosography revealed some excessive veins – in particular, a pair

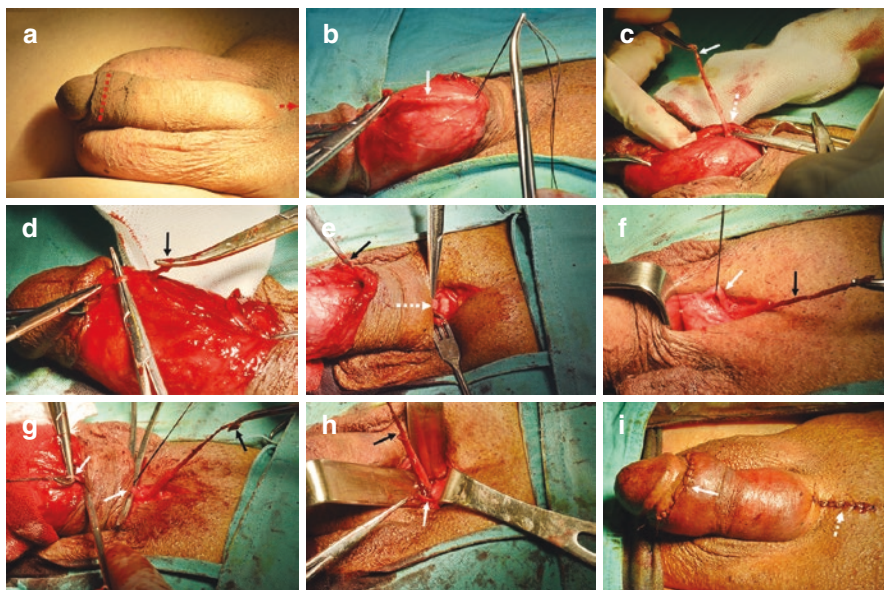


Fig. 50.4 Photos of the ongoing penile venous stripping process. (a) A circumferential (red line) and longitudinal pubic incision (red dotted arrow) are marked; then, we proceed to access the offensive veins. (b) The deep dorsal vein (DDV, arrow) is first identified and clamped with a hemostat distally and proximally. The visibility of the DDV is enhanced by employing a milking manipulation (mimicking a squeeze applied to a balloon) of the corpora cavernosa. Note that tag suture is made at the proximal portion of the DDV. (c) We advise an antegrade pull-through technique, an opening is made on Buck's fascia at each emissary vein, where the DDV trunk serves as a guide up to the penile base. (d) The distal retrocoronal plexus (black arrow) is meticulously ligated with as many

as 30 ligatures. (e) A longitudinal pubic incision is performed to relay the procedure while the DDV is passed underneath from the distal portion (black arrow) to the proximal portion (dotted arrow). Consequently, the DDV stump is tended to. (f) The DDV system (black arrow) is treated and, likewise, the cavernosal veins are managed (white arrow). (g) With the same maneuver, CVs are managed (white arrows). (h) The DDV (black arrow) and CVs (white arrow) are stripped. (i) Finally, the preputial (dotted arrow) and longitudinal pubic (arrow) wounds are fashioned with 5–0 chromic sutures. Note that neither an electrocautery nor a suction apparatus is required at any point in the entire procedures

of cavernosal and two pairs of para-arterial veins. The general existence of these veins was further confirmed in cadaveric dissections (Fig. 50.1). Since then, the revolutionary diagram of erection-related veins has been used as a blueprint for venous stripping surgery. Additionally, the latest method of the penile venous reconstructive method was developed; it involves a circumferential incision and a median pubic longitudinal approach and is conducted with an acupuncture-assisted local anesthesia on an ambulatory basis. Since the penile venous surgery is exclusively directed at the veins, damage to non-venous soft tissues is avoided. Tissues like nerves, arteries, and lymphatic vessels are spared. The amount of blood loss is negligible. Since June 1988, it has been administrated as an outpatient surgery under local anesthesia. Neither a Bovie nor a suction apparatus is required at any point in the pro-

cedure, resulting in minimal or no injury to any tissue other than the veins.

The latest penile venous stripping method. The most advanced method of penile venous stripping has been developed for treating impotence resulting from venogenic erectile dysfunction; it is depicted on the United States Patent and Trademark Office (USPTO) website (Fig. 50.4) [48]. First, a complete or semi-circumferential incision is made, and a circumcison is made if necessary (Fig. 50.4a). After hydro dissection is used, a more extensive de-gloving of the tissue layers superficial to the Colles' fascia is done. A milking manipulation can be applied to enhance the visibility of the DDV, which is stripped proximally (Fig. 50.4b). The surgeon then proceeds with a pull-through technique via an opening on Buck's fascia, up until the penile base, using a 6–0 nylon suture

(Fig. 50.4c). Then, distally, to the point of the retrocoronal plexus, the surgeon may need to make up to three dozen ligations of the emissary veins (Fig. 50.4d). Likewise, the paired cavernosal veins (CVs) are stripped. As a rule, the offending veins are surrounded by a perivascular sheath which should be opened for ligation. The paired proximal stump of the DDV and the CVs serves as a guide, and a median longitudinal pubic incision skin is performed for continuing the venous stripping by passing the venous stumps underneath the skin layer of the entire penile shaft (Fig. 50.4e). The DDV is then thoroughly stripped and then ligated as far as the pubic angle with the help of 85-degree hemostat (Fig. 50.4f). Similarly, the deep-seated CVs are tended to (Fig. 50.4g). The paired para-arterial veins (PAVs), which sandwich the dorsal arteries bilaterally, are meticulously ligated rather

than stripped. It is advisable to treat as the last step because an otherwise small vein will be markedly engorged after all larger veins are blocked at the tunical level. Meanwhile, all smaller veins between the tunica albuginea and Buck's fascia are identified and then treated similarly by squeezing the sinusoids of the corpora cavernosa (Fig. 50.4h). The wound is closed with 5–0 chromic catgut and 6–0 nylon sutures while an assistant stretches the penile shaft (Fig. 50.4i). A compression dressing is placed such that it encircles the penile shaft. Follow-up cavernosograms are routinely undertaken immediately following the operation. Post-operative cavernosograms categorically confirm that the CCs are an ideal chamber for intracorporal fluid retention as the penile crura, without exception, feature greater radiopacity than that of the femoral cortex (Fig. 50.5).

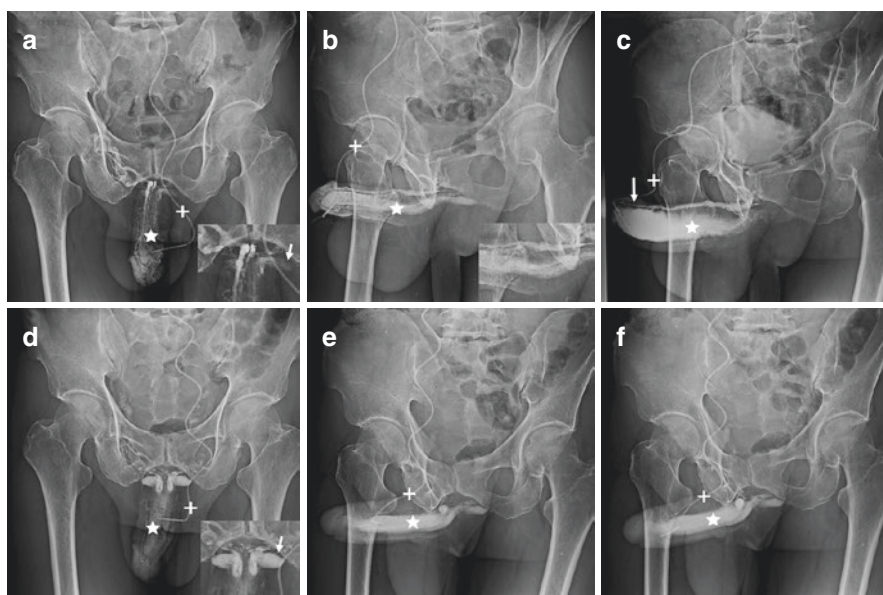


Fig. 50.5 Dural pharmaco-cavernosography of veno-occlusive dysfunction and cavernosographic evidence of erection restoration. (a) The first cavernosogram was obtained while a 10-ml diluted iohexol solution was intracavernously injected (white cross) into the corpora cavernosa (white asterisk), resulting in the immediate opacification of the erection-related veins, with faint radiopacity of the penile crura (white arrow). (b) A 30° oblique view film shows erection-related veins riding over the corpora cavernosa (white asterisk). (c) A pharmacocavernosogram was obtained 20–30 minutes after 20 μ g of prostaglandin E1 (test) was intracavernously injected. The bulk of the drainage veins were relatively prominent

despite the fact that a rigid erection was attained. Thus, veno-occlusive dysfunction was documented. (d). An A-P view post-operative cavernosogram disclosed that the offending veins were removed and that the intracorporal fluid retention of the penile crura was significantly enhanced (arrow). (e) A post-operative cavernosogram showed the penile venous stripping was complete. (f) Further intracavernous injection confirms that the corpora cavernosa is an ideal milieu for demonstrating intracavernosal fluid retention. Note that Panels D, E and F are all post-operative; in these, the penile crura is shown to have greater radiopacity than that of the femoral cortex

Our penile venous stripping addresses the drawbacks of conventional penile venous surgery and has been developed in tandem with the advances of penile tunical and venous anatomy associated with the erection mechanism. Since 1986, we have applied these seemingly unique venous stripping techniques in a large patient population under acupuncture-assisted local anaesthesia. We consistently encounter international patients seeking this treatment because of poor functional outcomes and unexpected adverse effects from prior penile vascular interventions. Although we currently recommend this treatment only to patients who do not respond to phosphodiesterase-5 (PDE-5) inhibitors, we rarely decline any patient who could benefit from the surgery. And while we readily acknowledge that PVS has been widely condemned, we believe the condemnation would be more appropriate if it targeted not the surgery itself but rather the precise method of surgical manipulation. We suggest its condemnation be retracted and re-evaluated in order to help men suffering from ED.

50.7 Endovascular Venous Embolization for Patients with Venogenic Erectile Dysfunction

Among options for venous treatment, penile venous embolization, with or without sclerotherapy, is an old paradigm newly revisited by many physicians – particularly the intervention radiologist. It is commonly believed to be minimally invasive and safe.

It aims to treat venogenic ED by limiting the outflow of blood in the penis. It may be technically easy for physicians to implant a coil or inject a sclerotic agent; it is commonly agreed that this is a minor procedure for the patient because of low morbidity. Consequently, penile venous embolization with or without sclerotherapy has been repeatedly attempted for treating venogenic ED. Although it is effective and safe in treating some vascular diseases, it has mixed results in treating ED. Given that it is

simple, safe, and relatively cost-effective, what great news it would be if it produced consistent outcomes!

Since late 2012, refractory ED has prompted six international males to seek our penile venous stripping, despite the fact that coil venous embolization with sclerotherapy had been performed elsewhere. Stunningly, uncontrolled coils not only lodged in the pulmonary artery but also made a right cardiac ventricle perforation (Fig. 50.3c, d), which was confirmed by a contrast computerized tomography. In one 25-year-old patient, acute chest pain occurred just seven days after the coils were inserted and resulted from the uncontrolled coils traveling to the right pulmonary artery. These side effects were accompanied by poor erection quality: an insufficient erectile rigidity (resulting from blockage of the deep dorsal vein and cavernosal veins distal to the preprostatic plexus) and a consistently unacceptable erection quality (resulting from failing venous blockage) was noted. Therefore, the efficacy of endovascular therapy is not without controversy, and its safety may not be presumed. This indicates that a penile venous embolization coil is at risk of migrating throughout the body once it is inserted in the main common drainage channel of the corpora cavernosa.

The efficacy of venous embolization warrants further research because it just treats vascular channels outside the corpora cavernosa. Pulmonary migration of coils inserted for the treatment of erectile dysfunction caused by venous leakage was reported in 1993. This can lead to symptoms such as acute chest pain and chronic cough. An uncontrolled coil is capable of traversing more than just the pulmonary arteries and may also perforate the ventricular wall. The tension of embolization coils varies by manufacturer, as does the coils' penetration ability. So potentially severe morbidity of coils, though rare, should be kept in mind, and patients should be informed of this possibility in choosing coil embolization for treating ED resulting from venogenic erectile dysfunction. The past three decades have seen in medicine and surgery an explosion of new technologies, devices, gadgets, and state-of-the-art tools. Penile vascular recon-

structive surgery and endovascular intervention have significantly benefited from this trend. Armed with these instruments and the appropriate technology, a skilled surgeon should be capable of treating ED through vascular intervention, but if and only if the sound method is used. We are hopeful that other surgeons can reproduce our successes.

50.8 Conclusions

Revolutionary advancements in our understanding of penile anatomy and erection physiology have been made in recent decades. These advancements have underpinned penile morphological reconstruction, penile implantation, and penile vascular reconstructive surgeries. Although vascular reconstructive surgery is still regarded as experimental by the larger medical community, our vascular reconstruction techniques, which are based on newfound knowledge of the penile anatomy, should be re-appraised. Arterial reconstruction has been shown to benefit young, healthy males who have sustained trauma. It has also been shown to benefit older healthy males, though this group is more likely to benefit if the vascular reconstructive surgery includes both arterial revascularization and veno-arterialization. In summary, the reproducible penile venous stripping procedure, which has been developed and refined over several decades, is showing promise as a viable solution – for any age group – to treat venogenic erectile dysfunction.

Key Summary Points

- Erectile dysfunction is a noteworthy problem with a large impact on the quality of life affecting many men across all age, particularly awkward in those who are young and robust with a necessity of healthy erectile function.
- Despite variation between studies secondary to a lack of standard surgery methods or strict criteria to define “satisfactory sex,” penile arterial reconstruc-

tive surgery support its adequacy in young men who have sustained arterial trauma and in older men with a localized arterial occlusive disease.

- The tunica albuginea of the corpora cavernosa is a bi-layered structure with a 360° complete inner circular layer and a 300° incomplete outer longitudinal coat upon which penile erection-related vasculature interacts. The erection-related veins are composed of a deep dorsal vein, a pair of cavernosal veins and 2 pairs of para-arterial veins which drain the cavernosal sinuoids via specific emissary veins between Buck’s fascia and the tunica albuginea.
- Apagogical hemodynamic studies on defrosted cadavers substantiate the penile vasculature playing a pivotal role in reaching erection rigidity and veno-occlusive mechanism occurring at the tunica albuginea; accordingly, a surgeon seeking to restore a patient’s erectile capability must treat penile vasculature intertwined with tunica albuginea.
- Penile venous stripping surgery has been shown to be effective in correcting corporal veno-occlusive dysfunction, with outstanding results, since 1986. The conventional complications such as irreversible penile numbness and permanent deformity have been virtually avoidable with the use of new venous ligation techniques rather than electrocautery.
- Penile vascular reconstructive surgery is viable if and only if the surgical handling is done properly and soundly. With the dissemination of the correct training, it ought to be procurable in practice worldwide.

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Circumcision: Avoidance and Treatment of Complications

51

Marta Skrodzka and Peter Malone

51.1 Introduction

Circumcision has been practiced in large numbers for millennia. Early Egyptian paintings and mummies have shown that the technique has been practiced as early as 4000 BC [1] and in 2007 the World Health Organisation estimated that 30% of the world's adult male population had been circumcised [2]. One might have thought that, given how long we have been performing this operation and the number of times it has been done, we might have perfected the technique by now. Not a bit of it. Any genitourinary tertiary referral centre will be all too familiar with patients referred in because the circumcision has not been successful or worse [3]. This may be due to poor hygiene or technique, but, occasionally, it can be a technically difficult operation, either due to the severity of the pathology, particularly lichen sclerosus (LS), or occult anatomical variations, for example some patients with a forme fruste of hypospadias have a gossamer urethra which is more liable to injury [4].

Other anatomical variations, such as a buried penis with mega-prepuce, may not be hidden but the signs can be subtle to the inexperienced [5]. Rare conditions such as pilonidal sinus of the penis require amendments to the technique [6]. Similarly obese adults and paediatric patients require a more careful approach due to the tendency of the penis to become buried in the suprapubic fat pad [7].

The most common reason that circumcision is performed, however, is for religious and cultural reasons. Most consultant genitourinary surgeons, including the authors of this chapter, have little experience of this as it is usually performed by a trained religious practitioner, for example a Mohel in the Jewish faith, a trained nurse, operative or general practitioner. This chapter, therefore, will look at the way to deal with the complications of religious and cultural circumcision and how to perform a circumcision for medical indications, in a way to avoid or at least minimise the risk of complications.

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51.2 Medical Indications for Circumcision

The most common indication is for phimosis secondary to lichen sclerosus [8] although it can also help other forms of glans inflammation, such as Zoon's balanitis [9]. Circumcision is likewise advised in those few adolescents and

adults with a persistent congenital phimosis or a relative phimosis (a foreskin which will retract when the penis is flaccid but is not slack enough to allow painless retraction when the penis is erect) to allow hygiene and painless intercourse [10]. Preputioplasty is an alternative for this group. Circumcision is performed for malignancy and pre-malignant change, not only of the foreskin, but also the glans, as PeIN (Penile Intraepithelial Neoplasia) of the glans can regress after removal of the foreskin [11]. It has increasingly been used as prophylaxis against sexually transmitted diseases, particularly HIV in those areas where the incidence is high, e.g. sub-Saharan Africa [2]. Rarely it is required to stop repeated infections of the foreskin [9] and has been also advocated for the management of recurrent urinary tract infections in boys, although a recent meta-analysis found little to justify its routine use for this indication [12]. It is indicated in the very rare cases of pilonidal sinus of the penis where the technique needs to be modified to remove the hair containing sinuses [6]. The foreskin in penile lymphoedema can be so large and unsightly, that circumcision is beneficial. In mild cases circumcision alone can suffice, but with more severe cases the penile shaft and scrotum can also require debulking with or without skin grafting [13].

51.3 When Not to Operate

Circumcision can be life-saving or curative of disabling symptoms, but the consequences of complications can be tragic. The best way to avoid complications is not to operate without good cause, especially in children with phimosis.

At birth the prepuce is usually phimotic and adherent to the glans with a shared epithelium between the glans and prepuce, frequently referred to as preputial adhesions. As the child matures the adhesions separate and the foreskins slackens to allow it to retract and reveal the glans penis. Gairdner (1949) [14] showed that only about 5% of babies under 6 months had a retractile foreskin but this had risen to 92% by the age of 5 and Øster (1968) [10] showed that this had risen further to 99% by the age of 14–16 (Fig. 51.1). Similarly the incidence of congenital preputial adhesions falls from 63% in 6 year olds to only 3% in 16 year olds without intervention [10]. An inability to retract the foreskin in children, by itself, therefore, should not be an indication for circumcision. The authors' experience is that congenital preputial adhesions almost always disappear by adulthood, as opposed to those that develop in adults which are usually secondary to lichen sclerosis [15].

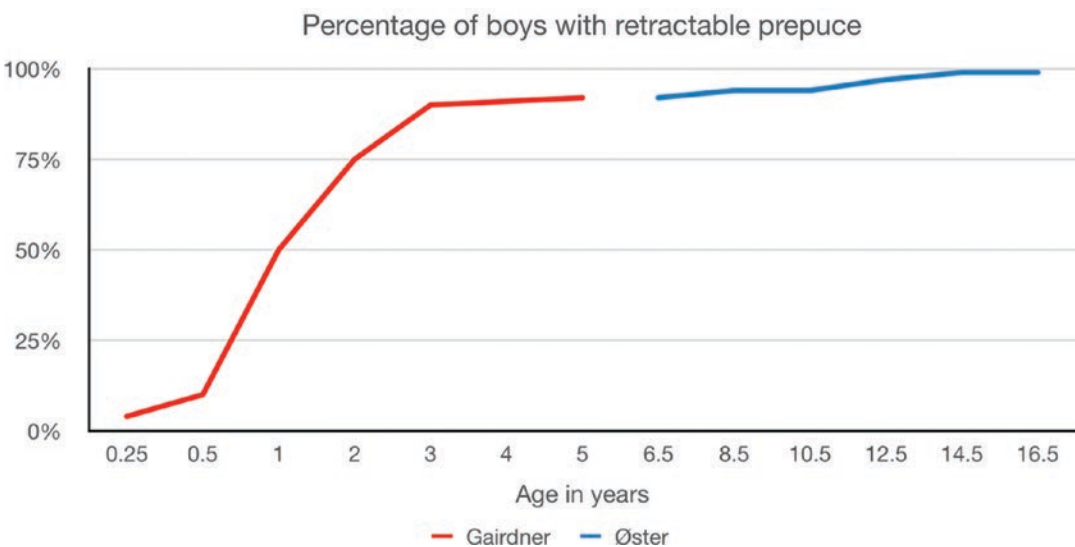


Fig 51.1 The percentage of boys with a retractable foreskin as they get older

51.3.1 Congenital Megaprepuce and Buried Penis

This relatively rare condition is frequently referred to urologists for treatment of phimosis by general practitioners. The key to the diagnosis is awareness of the paucity of shaft skin, and, in the case of congenital megaprepuce, the typical penoscrotal swelling with micturition. Urine can frequently be expressed by pressure applied in this area [16]. This is due to an extensive sac formed by a very large, redundant, inner prepuce, trapped by short, phimotic penile shaft skin. Circumcision, under these circumstances, is disastrous as it converts a congenital megaloprepuce into a trapped penis. In this case penoplasty is required, where every millimetre of shaft skin is preserved and, if necessary, the shaft is partially covered with inner preputial skin. Surgeons seeing paediatric patients for penile problems should familiarise themselves with this condition for fear of inappropriately removing what little shaft skin is available.

51.4 Complications of Circumcision

It is a fair adage that anything that can go wrong will go wrong (Murphy's law attributed to John Stapp). The reported complications of circumcision bear testament to that law. They include death, bleeding, infection, sepsis, loss of part or all of the penis, taking too much or leaving too much inner preputial or penile shaft skin, meatal stenosis, urethral injury, urethrocuteaneous fistula, poor cosmetic outcome, lymphoedema of the penis, particularly the remaining inner prepuce, decreased sensitivity of the glans, inclusion dermoid cysts, failure to expose the corona by releasing preputial adhesions or the formation of skin bridges. In addition, in cases where the operation has been performed to treat lichen sclerosus, it may fail to halt the progress of the condition, particularly in the obese.

When looking at the complications of circumcision there is obviously a difference between surgery in underdeveloped countries, frequently

done by lay practitioners or nurses in a rural setting and surgery performed by trained urological surgeons under aseptic conditions with ready access to emergency care in the event of complications. The incidence of complications and their severity are so different that it is difficult to compare them in any one paragraph about a particular complication. That is not to say that severe complications aren't reported in major surgical centres in affluent countries, just that they are less frequent by an order of magnitude although some, like tetanus [17] are not seen when surgery is done under aseptic conditions in a vaccinated community.

51.4.1 Circumcision in Developing Countries

In parts of the world, circumcision is performed as a 'right of passage' to manhood by lay practitioners in a rural environment. Under these circumstances severe infections including tetanus [17] are not uncommon and can be devastating or lethal. Meel (2010) [18] reported 25 deaths in a single large regional hospital in the Mthatha district of South Africa during the 2 year period 2005/6. The average age of the deceased was 17.6 years with the youngest being 12. Appiah et al. (2016) [19] reported 72 cases of circumcision related injuries during an 18 month period referred in to a single teaching hospital in Ghana. 78% of the complications were urethrocuteaneous fistulae with 3 (7%), complete amputations. The mortality, however, seems lower than in the South African series, probably because the majority of these operations were performed by nurses in a rural hospital setting.

51.4.2 Complications in Developed Countries

Weiss et al. (2010) [20] reported a systematic review of circumcisions in male neonates, infants and children. He reviewed 52 papers from 21 countries which included sufficient information to estimate the frequency of adverse events.

Retrospective analysis of the complications of child circumcision undertaken by medical providers gave a range of serious adverse events from 0% to 2.5%. Talini et al. (2018) [3], however, reported that, in a total of 2441 circumcisions in Brazil, 3.27% required surgical intervention for complications and Thorup et al. (2013) [21] reported a 5.1% significant complication rate when late complications were included. Comparison between different series is difficult due to the lack of standardised collection and reporting of data.

51.4.3 Death

Death following circumcision is fortunately very rare. Nevertheless about 16 deaths a year were reported in England and Wales from 1942 to 1947 mainly from anaesthetic complications, bleeding and infection [14]. The significance of bleeding in small babies should not be underestimated. The circulating blood volume of a 3.4 kg neonate is only about 300 ccs so what would be a relatively small bleed in an older child can exsanguinate a newborn baby. Although rare, in this day and age in affluent countries with a good health care system, fatalities are still occasionally reported, so this eventuality must be taken into consideration in the decision if and where to operate [22]. Furthermore, for every death there are usually several near misses [22] so the mortality rate always underestimates the incidence of severe complications.

51.4.4 Infection

Local infections are usually responsive to antibiotics and heal well without the necessity for surgical intervention. Nevertheless, even in a hospital environment, rare cases of severe infection including necrotising fasciitis have been reported [23] and patients and parents should be advised to seek medical help urgently if there are signs of systemic infection (sepsis) or spreading cellulitis. Prophylactic antibiotics have not been shown to be beneficial, and are not free of mor-

bidity. In a non-randomised study of 84,226 patients, of whom 10.6% had received surgical antibiotic prophylaxis, Chan et al. (2017) [24] showed there was no reduction in the rate of surgical site infection by using prophylactic antibiotics ($p = 0.5$), but, not surprisingly, a significantly higher rate of a peri-operative allergic reactions ($p = 0.0004$).

51.4.5 Taking Too Much or Too Little Shaft Skin or Inner Foreskin

It is self-evident that this should be an avoidable complication, unless done deliberately as necessitated by the severity of the initial pathology e.g. for malignancy or severe lichen sclerosus. Taking too little is obviously better than taking too much as more can be taken at a later date. Equally there is no real reason why it cannot be judged accurately. The key is to judge where to place the inner and outer incision lines.

51.5 Technique of Circumcision: One Way to Perform a Circumcision

The penis is anchored to the underside of the symphysis pubis by the diverging corpora and the suspensory ligament. In patients with a large supra-pubic fat pad, the overweight, the obese, babies and young children, the skin is pushed forward. In the obese, the penis can be an internal organ with the shaft skin empty. It is important, therefore, to compensate for this, when deciding where to cut the outer prepuce, and the easiest way is to push the base of the penile shaft skin down to the symphysis pubis before marking the place of the incision. The method of marking is not too important but we favour the use of clips to mark the dorsal and ventral limits of the incision (Fig 51.2b and c). Genital skin does not cut easily unless it is on the stretch, but it is important to mark the limits of the incision before this is done for fear of distorting the anatomy. With a further 2 clips at the tip of the foreskin, a straight cut is made in-between the clips under tension

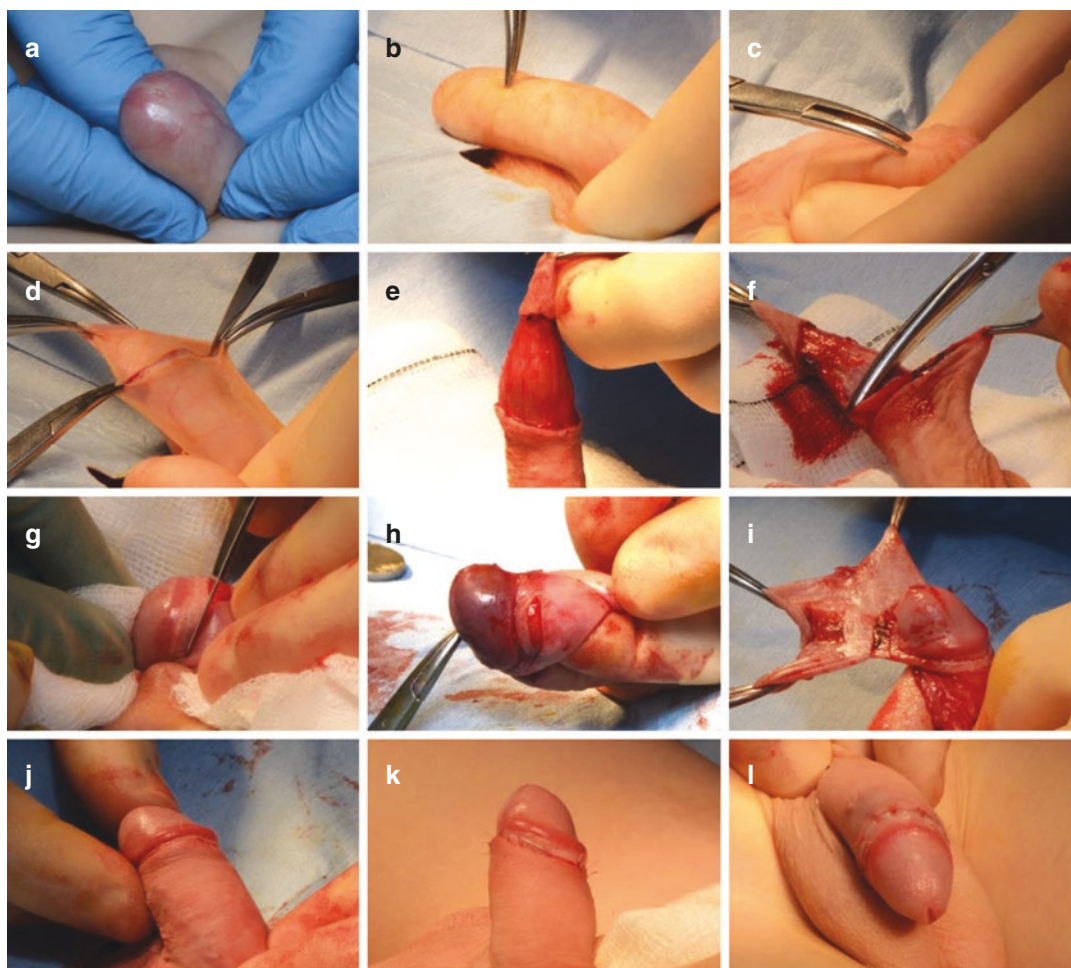


Fig. 51.2 A technique of circumcision. (a) The penis of a child with a pinhole phimosis caused by lichen sclerosis. (b) The dorsal shaft is marked with the base of the penis pushed against the symphysis pubis. (c) The line of the corona is carried around the penis ventrally and marked in the midline. (d) 2 further clips are placed at the tip of the foreskin at 6 and 12 o'clock and straight incision made from just inside the proximal pair of marking clips on both sides. These clips are then removed and the incision completed circumferentially. (e) This leaves the shaft skin perfectly shaped to match the inner preputial skin, later. (f)

The dartos is cut in the same line. (g) The inner preputial skin is scored about 5 mm from the corona. (h) On the ventral side this is made easier by placing a finger behind the prepuce to stabilise the penis and make it easy to score the inner prepuce precisely. (i) The foreskin is held well away from the urethra which is protected whilst the foreskin is removed. (j) The inner prepuce and shaft skin should match perfectly. (k) Fine 6/0 (5/0 in adults) dissolvable sutures complete the operation after bipolar haemostasis. (l) Dorsal view of the finished operation

(Fig 51.2d) and when the circumferential incision is completed it produces a perfectly rounded end to the shaft skin to match the cut end of the inner prepuce (Fig 51.2e and j). The inner incision can be judged and marked or scored by direct vision (Fig 51.2g) and this is facilitated on the ventral aspect, particularly in small children, by placing a finger behind the prepuce to immobilise the penis

and stretch the skin (Fig 51.2h). It is important not to leave too much inner preputial skin as this can become swollen resulting in a lymphoedematous ring around the corona. This poor cosmetic result frequently requires surgical excision of the ring although it is usually cured by this maneuver. A box stitch at the frenulum should be avoided as it frequently results in a skin tag. It is much better to

control the frenular vessels prior to skin closure and just close the skin with perfect skin to skin apposition (Fig 51.2k-l). The dartos should either be closed separately in a 2 layer closure or included into the skin closure to prevent a concave ring just proximal to the corona.

51.6 Lichen Sclerosus

Lichen sclerosus is a progressive inflammatory condition that mainly affects genital skin, although rare, non-genital presentations have been reported [15]. Although it has been postulated that it is an autoimmune disease, the cause is unknown. It has been associated with certain Human Leukocyte Antigen subgroups but not convincingly. What does seem clear, however, is

that it is caused by contact between urine and genital skin folds of susceptible individuals [15]. The evidence for this is overwhelming.

1. The pattern of distribution in males and females is strikingly different. While girls and women usually have a figure of eight pattern around the urethra and anus, peri-anal LS is virtually unheard of in males [15].
2. In patients with a perineal urethrostomy, lichen sclerosus frequently develops at the site of the urethrostomy [25].
3. In children who have lichen sclerosus but still have congenital preputial adhesions, when the adhesions are separated, at the time of circumcision, the underlying skin is seen to have been protected by the adhesions (Fig. 51.3).



This part of the penis was protected by preputial adhesions which were separated at the time of circumcision

Penis of a child showing marked signs of lichen sclerosus persisting after circumcision.

Fig. 51.3 The penis of a boy with lichen sclerosus to show that the glans skin, under the preputial adhesions separated at the time of circumcision, is not affected by the lichen sclerosus

4. Patients with LS have a much higher incidence of urinary dribbling than patients without LS [15].
5. Patients with persistent skin folds over the penis after circumcision have a higher rate of recurrence [26].

The aim of circumcision, therefore, is to stop the trapping of urine between opposing genital skin folds. Partial circumcision, therefore, has no part to play. If the circumcision is being performed for cultural or religious reasons it is only necessary to please the patient, or parents of the patient, about the cosmetic appearance after surgery. When performed for medical reasons there is a therapeutic goal. In the case of malignancy it is obviously to remove the cancer but also to reduce the area for future cancers to develop. Under these circumstances what is known as a radical circumcision is performed where no inner preputial skin is left and the shaft skin is approximated to the corona. When surgery is performed for lichen sclerosis then a small cuff of inner preputial skin can be left but not so much as to allow urine to be trapped by opposing skin folds. Depasquale et al. (2000) [8] showed that circumcision was effective in con-

trolling lichen sclerosis with only 3.9% of patients, whose pathology was confined to the foreskin and glans, with ongoing LS requiring resurfacing after the circumcision. Nyatsanza et al. (2015) [26] reported a higher rate of recurrent LS in patients where skin folds, covering the glans penis, persisted after surgery.

51.6.1 The Difficult Circumcision

One of the features of lichen sclerosis, in addition to the secondary phimosis and skin changes on the foreskin and glans, is the tendency to form secondary preputial adhesions [15]. These adhesions must be distinguished from the adhesions seen so frequently in babies and children, which are a normal part of the development of the penis and nearly always separate, of their own accord, before adulthood [10]. In patients with lichen sclerosis, they are a frequent finding at circumcision, requiring them to be separated from the corona, before undertaking the operation [27]. Occasionally, however, they are so extensive and dense that the plane between the glans and inner prepuce is lost (Fig 51.4a) and attempts to find it

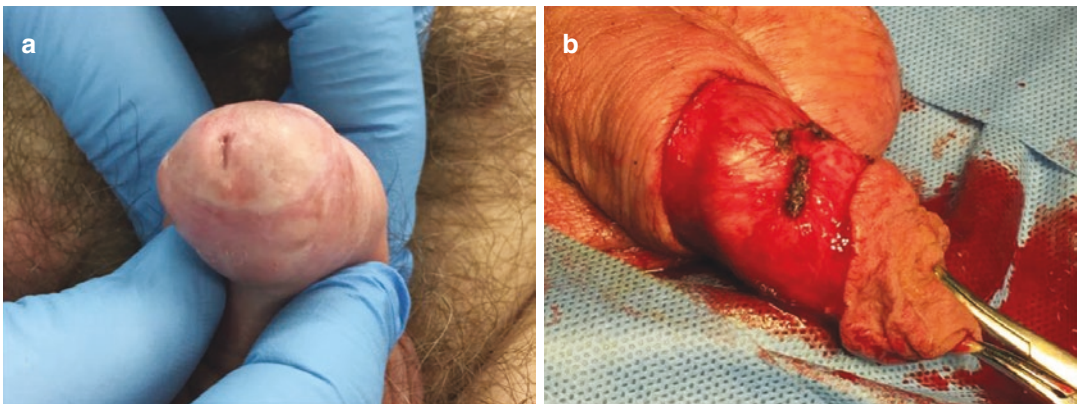


Fig. 51.4 The difficult circumcision when the foreskin is welded to glans penis: The ROLOCS procedure (Restoration Of the Lost Obscured Coronal Sulcus). (a) The penis of a man with marked preputial adhesions where there is no obvious plane between the foreskin and glans. (b) The shaft skin is incised as for a standard circumcision exposing the corona under the dartos. (c) The dartos is picked off the glans in a relatively bloodless

plane preceding antegradely until the point of fusion of the glans and foreskin is reached and the foreskin removed. (d) The shaft skin is sutured to the dartos just under the corona taking care not to pick up the urethra. (e) 2 weeks post operatively the glans is sloughy and can be sore. (f) By 6–8 weeks, however the glans heals over without the need for skin grafting and with the corona now exposed

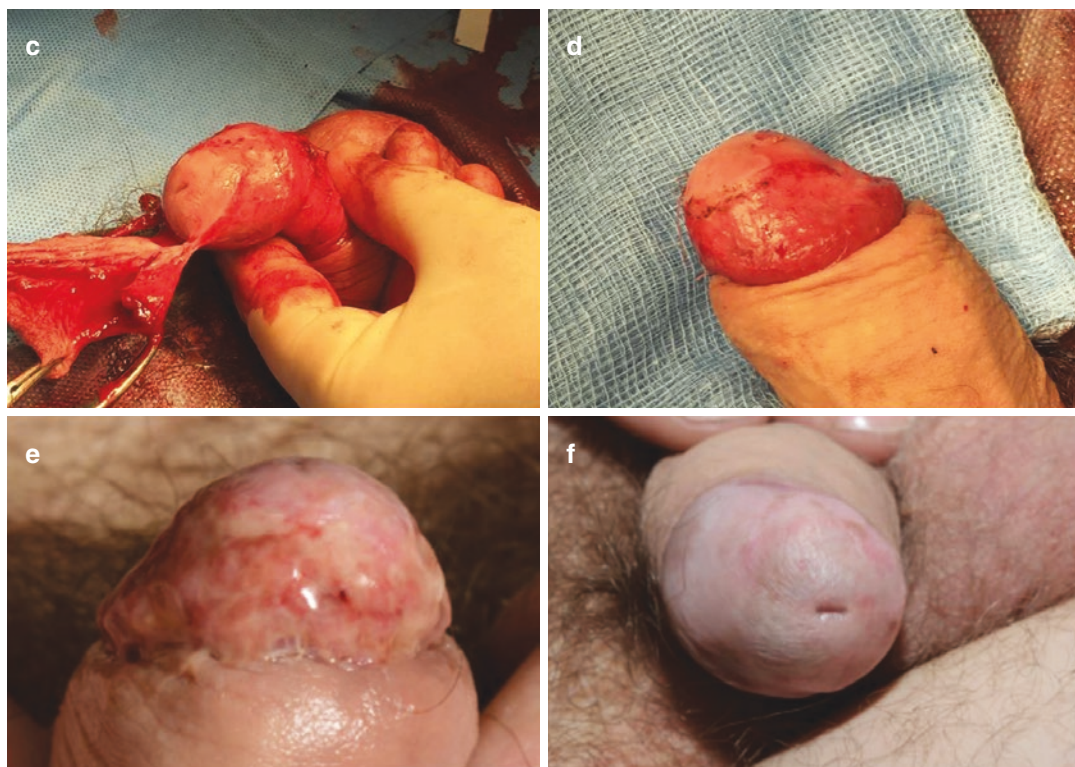


Fig. 51.4 (continued)

risks de-epithelialisation of the glans with the requirement for skin grafting. Alternatively the adherent part of the prepuce can be left in situ but this partial circumcision is unsightly and frequently painful, especially during intercourse. The authors recently presented their experience of such cases using the ROLOCS (Restoration of the Lost Obscured Coronal Sulcus) technique [28] which involves an antegrade dissection just outside the fused epithelia of the glans and prepuce in a relatively bloodless plane (Fig 51.4b–d). Over the next 6–8 weeks the glans becomes raw and can be sore (Fig 51.4e) before it re-epithelialises, presumably from trapped nests of epithelial or stem cells to form a normal looking and feeling glans with good sensation (Fig 51.4f). Although all 22 patients in this series healed without problems the numbers are relatively low so it would be a wise precaution to warn the patients of the possibility of the need for skin grafting if this fails to happen. There should be a

window of opportunity, if the glans granulates, to apply a graft without letting it heal by secondary intention. The need to expose the corona in these cases was accentuated by the high incidence of penile intra-epithelial neoplasia in the group and cases of squamous cell carcinoma just at the point of fusion [28].

51.7 Meatal Stenosis

Meatal stenosis is frequently seen after circumcision in two different circumstances.

51.7.1 Early Circumcision for Cultural Reasons

In neonates and babies the foreskin has a protective effect on the epithelium of the glans around the meatus. When this is removed, as a result of

circumcision, it may render the delicate meatus liable to scarring by exposure and ammoniacal dermatitis.

51.7.2 Meatal Stenosis with Lichen Sclerosus

Lichen sclerosus, as well as causing phimosis, is well known to involve the urethra causing strictures encompassing stenoses from just the very tip of the meatus to full length urethral involvement. It is thought to start distally and progress down the urethra by a process of advancing squamous metaplasia [29]. It is not surprising, therefore, that patients with severe lichen sclerosus will develop meatal stenosis detected either at the time of circumcision or afterwards. It is not so much a complication of circumcision as of the condition that necessitated the need for it although it is common for the stenosis to develop or worsen in the 6–12 weeks following surgery. Follow up of all children and adults with perimeatal involvement is mandatory to pick up this complication.

51.7.3 The Treatment of Meatal Stenosis

When the circumcision has been done for cultural or religious reasons as a baby or child the meatal stenosis, even when severe enough to cause renal failure [30], is always confined to the very tip to produce a pure meatal stenosis (PMS). The tissues are usually supple and it is easily cured by a simple ventral meatotomy. The authors prefer to do this without clamping and a simple ventral cut of sufficient length to give an adequate meatus gives good results. The cut urethral and glans epithelia are then sutured with interrupted fine (7/0 in children or 6/0 in adults) polyglyactin sutures which are haemostatic as well as ensuring perfect epithelium to epithelium alignment. Recurrence is, at worst, exceedingly rare [31].

When the stenosis is part of the inflammatory and cicatrising effect of lichen sclerosus, it becomes a more difficult condition to treat.

Simple meatotomy has a significant recurrence rate as does urethral dilatation [32, 33]. The meatus tends to contract after surgery and unless the ventral meatotomy is of sufficient size to create a hypospadiac meatus, then it is frequently insufficient to prevent recurrence. An alternative is to perform a dorsal meatoplasty or both [34]. The reason that a dorsal incision is not routinely used is that the thickness of the spongiosus, on the dorsal glans, means that when the urethral and glans epithelia are opposed, the glans becomes distorted and looks unsightly. This can be overcome by an inverted V releasing incision which allows the glans to reform a natural shape and the meatus to become slit like. A slit meatus is important as it reduces the risk of a spraying stream. The recurrence rate is low, as is the production of a spraying stream whereas the patient acceptability of the cosmesis is good. A diagrammatic illustration of the technique was published in the British Journal Of Urology International [35] and the results replicated in other centres [36, 37].

On occasions the thickness of the glans skin is so great that it lacks the suppleness to perform either a dorsal or ventral meatotomy/meatoplasty. Providing the stenosis is superficial and doesn't extend into the navicular fossa then it can be cured by glans resurfacing where the thick abnormal glans skin is replaced by a split skin graft [38]. This is particularly beneficial where there is any malignant change involved. Lichen sclerosus is almost certainly a driver to malignant change in the penis [15] so removal of the glans skin kills 3 birds with one stone. It removes the unsightly and often painful skin, reduces the risk of malignant change and cures the meatal stenosis in one operation.

When the stenosis extends more than two or three millimetres into the navicular fossa then meatoplasty has such a high recurrence rate that it should not be attempted. Under these circumstances a buccal mucosa graft distal urethroplasty seems to give the best chance of long term relief of obstruction. Genital skin inlay surgery nearly always, given the passage of time, ends up with a recurrent stenosis [39]. An algorithm for the treatment of meatal stenosis is given in below. (Fig. 51.5).

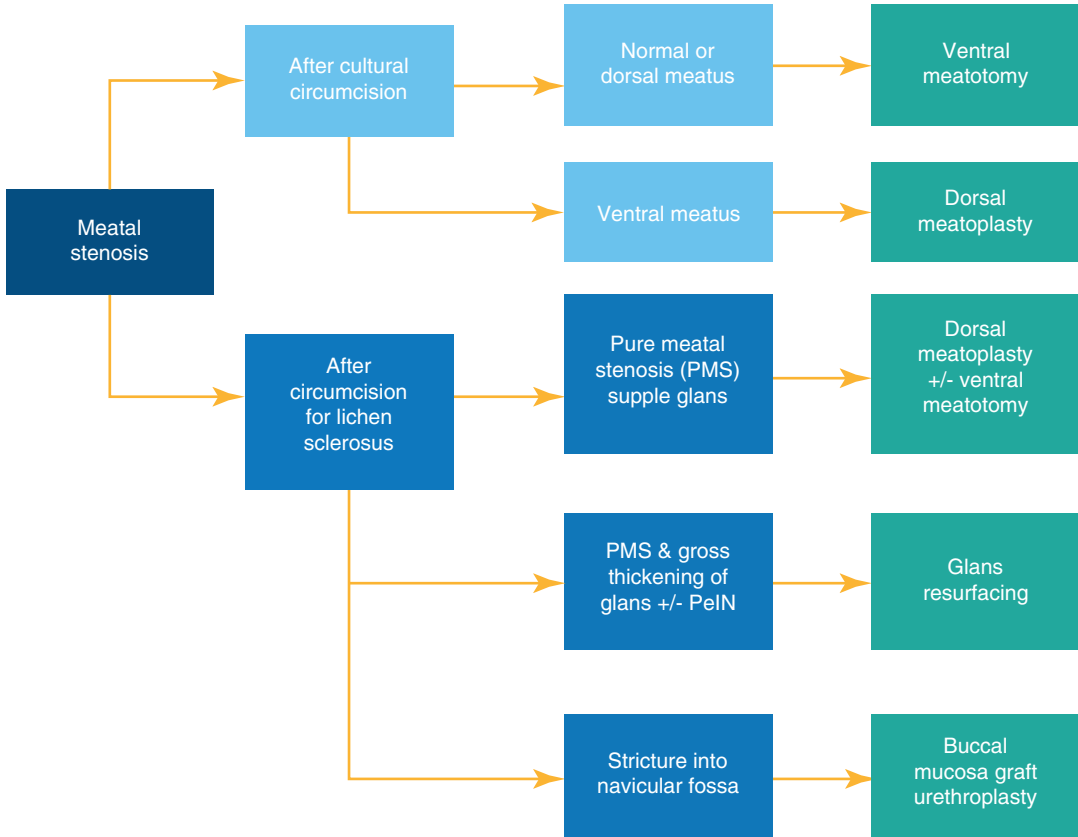


Fig. 51.5 An algorithm for the treatment of meatal stenosis after circumcision

51.8 Injury to the Urethra

For the normal urethra and a competent surgeon, urethral injury during circumcision should be a rare event. Holding the inner preputial skin well clear of the urethra (Fig 51.2i) when cutting it is the best way to avoid this complication although it can also be caused by a stitch, aimed either at haemostasis or restoration of the dartos layer, that inadvertently picks up urethra. Edney et al. (2004) showed, in a porcine model, that urethrocuteaneous fistulae form along these suture lines [40]. This is made more likely if the underlying urethra is poorly formed [4] or a megalourethra [41].

Methods of surgical correction of urethrocuteaneous fistulae have been based on excision of the fistula tract and repair of the urethra and skin with interposition of a layer of connective tissue, usually dartos, between the urethra and skin to

try and prevent recurrence [42]. Repair is prone to recurrence and coronal fistulae have a much higher rate than those situated more proximally. Most urethrocuteaneous fistulae arise as a consequence of hypospadias repair and many surgeons prefer to redo the repair rather than attempt to close these distal fistulae [42]. Karakus et al. (2017) [43] reported a method of closure using tight ligation of the fistula tract by simple tract ligation and Malone reported the PATIO repair where the fistula tract is Preserved And Turned Inside Out (PATIO) acting as a flap valve to prevent the ingress of urine and obviating the need for a catheter [44]. Both tight ligation and the PATIO repair avoid sutures at the urethral closure site, but the latter has the advantage that it can be used for larger fistulae and there have been several reports from different centres worldwide confirming the efficacy of the technique [45, 46].

51.9 Loss of Sensation

It has been reported that circumcision results in reduced sensation in men [47], yet it is difficult to quantify. Morris et al. [48], however, reported that, when done for medical reasons, no reduction in sensation was observed. It seems wise to include loss of sensitivity as a potential complication of routine circumcision, when consenting the patient. Equally when done for a painful condition such as LS or simple phimosis compromising quality of sexual life, the procedure may well improve the pleasure of intercourse [48].

51.10 Loss of Part or the Entire Penis

This, most disastrous of all complications of circumcision apart from death, can be caused by several causes.

51.10.1 Diathermy

All end organs are more vulnerable to diathermy damage as, in the case of the penis, the organ can be affected by both direct burns but also coagulation of the blood supply to the whole organ as the current is channeled through the base of the penis [49]. In monopolar diathermy the current runs from the diathermy forceps to the pad on the trunk or leg necessitating the passage through the base of the penis whereas, in bipolar diathermy, the circuit is completed between the 2 arms of the forceps. Bipolar is intrinsically safer [50]. The obvious way to minimise the risk of penile injury from diathermy is to use bipolar diathermy on the minimal setting needed to achieve haemostasis [51]. Monopolar diathermy is not necessary to achieve good haemostasis for a circumcision and neither is it necessary to use much power to coagulate the vessels using bipolar, even on an adult with large veins. On the rare occasions that the vessels are deemed too large for modest bipolar diathermy a fine tie will safely manage the problem.

51.10.2 Sepsis

Circumcision, done in aseptic surroundings rarely gives rise to infection that threatens the integrity of the penis. This complication has been dealt with earlier in the chapter. Obviously in the acute stage broad-spectrum antibiotics, debridement and drainage of any collection are the mainstay of treatment. Later reconstruction may be possible to give the patient the best approximation to normality.

51.10.3 Accident

There are rare occasions where part of the penis is removed as part of a circumcision. The sooner this is realised by the surgeon and acted upon then the greater the chance of salvaging the organ. Penis reattachment surgery has been shown to be possible on several occasions [52–54] so it is vital that the penis is cooled and the surgeon contacts a tertiary centre capable of carrying out the microsurgery required for reattachment. All regions, and the tertiary centres within them, should have an action plan for this eventuality with, either an on-call team of surgeons, or at least the knowledge of where to send the patient if it is not available in their unit. Although microsurgical reconstruction of the blood and nerve supply gives better results there are reports of successful reattachment, without microvascular anastomoses for distal injuries in places where those facilities are not available [54].

51.10.4 Penile Reconstruction

If part of the penis has been lost then the principles of reconstruction are based on the severity of the injury.

51.10.5 Making the Best of What Is Left If There Is Sufficient Penis Remaining

The techniques used here are based, in part, on the surgery devised and routinely employed in

penis conserving surgery for penile cancer. Bracka first described the technique of glansectomy [55]. The premise of this surgery is that when a split skin graft is applied to the raw bodies of the corpora cavernosa after the glans has been removed, it can look remarkably like a normal glans. The same technique can be applied after partial penectomy, particularly if the urethra is centralised to its normal position (UCAPP – urethral centralisation after partial penectomy), wrapping the corpora cavernosa around it prior to applying the split skin graft [56]. Loss of shaft skin is best dealt with either by a full thickness graft to give the most supple skin to allow for erection [57] or, alternatively, to embed the penis in the scrotum and use scrotal skin to recover the penile shaft. The latter is usually done as a two-stage procedure but gives cover of the shaft with full thickness genital skin, most able to expand with erection, without the worry of graft loss but at the expense of the need for depilation [58]. Trying to improve the appearance of increased length by division of the suspensory ligament with or without silicone spacers to prevent reattachment has been advocated [59] but not always to the satisfaction of the patient [60].

51.10.6 Recreating a Penis If There Is Insufficient Penis Left

In the very sad event that the whole penis is lost and cannot be reattached, then the options are either free flap phalloplasty such as: radial artery phalloplasty [57] and musculocutaneous latissimus dorsi flap [61] or pedicled flap e.g. anterolateral thigh flap [62], that does not require microsurgical anastomoses. A penile implant can be inserted into all phalloplasties to allow intercourse. Rarely and controversially [63] in the case of babies, gender reassignment has been suggested [64].

Recently, however, programmes have culminated in penile transplant surgery being performed [65, 66]. The ethics of this programme are vexed as death is not likely as a direct result of the loss of the penis whilst immunosuppression can give rise to chronic allograft vasculopa-

thy, malignancy and sepsis all of which can significantly reduce the life expectancy of patients [67]. In some cases, however, the psychological and social consequences of penile loss can be devastating and not all cultures accept penile reconstruction by phalloplasty which justifies the surgery [68], although careful selection must be paramount.

51.11 Conclusion

Circumcision is an ideal operation for junior surgeons to begin to learn the art of open surgery. Like all surgery, however, it can only be undertaken if the principles are understood, training given and a senior, experienced hand is available when it turns out to be difficult. This chapter has illustrated a way to perform a routine circumcision, deal with the difficult circumcision, and gives an outline of the principles used to deal with complications of the operation or the disease that necessitated the operation in the first place.

Key Summary Points

- It has been estimated that 30% of the world's population have been circumcised and it is one of the earliest operations ever to be described.
- Despite the huge number of operations that have been performed a relatively high rate of complications is still reported.
- In deprived populations, the rate and severity of complications, including death and life changing sequelae, is depressingly high. Even in first world environs the rate is significant.
- One of the commonest complications is meatal stenosis. We present an algorithm for its treatment.
- Bipolar diathermy is safer than monopolar.
- Care should be taken in babies and the overweight, especially, not to remove too much shaft skin.

- Surgeons should be aware of anatomical variations such as mega-prepuce.
- Circumcision can be challenging when the foreskin is welded onto the glans and we present a technique to overcome this problem.
- Urethro-cutaneous fistulae, following circumcision, can be repaired by excision of the tract or by its preservation, using it to act as a flap valve to prevent the ingress of urine to facilitate healing.
- It is possible to reattach the penis when removed accidentally and all districts should have a plan for this eventuality.
- When the penis is partially lost then the techniques used in its reconstruction are based on those used in penis preserving surgery for penile cancer.
- When the whole penis had been lost then reconstructive phalloplasty or penile transplant are possible.

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52.1 Introduction

Microsurgery remains a critical skillset for physicians treating male factor infertility. Although technology and science have advanced dramatically in recent times, many of the concepts and techniques of male fertility microsurgery remain unchanged from those described decades ago. Indeed, some of the earliest descriptions of surgical management of varicoceles date back to the first century AD [34]. Even the newer techniques (microscopic testicular sperm extraction [micro-TESE]) are often the result of advances in other aspects of infertility technology (in-vitro fertilization and intracytoplasmic sperm injection [IVF/ICSI]) rather than changes in surgical techniques and principles.

The current chapter is outlined to provide a high-level overview of microsurgery for infertile males. Brief mention will be made of appropriate equipment and logistical considerations, after which each of the major microsurgical procedures will be described, including micro epididymal sperm aspiration (MESA), microTESE, varicocelectomy, and vasectomy reversal (VR). Each section will be divided to review indications

for the procedure, description of technique, and outcomes, with illustrations provided to highlight key surgical steps. It is important to recognize that every microsurgeon will differ slightly in their approach to performing these procedures, however, many of the key steps and principles remain similar and are consistent with long-recognized principles of good surgical technique. Where appropriate, a discussion of relevant publications relating to indications and outcomes will be reviewed and summarized.

52.2 Microsurgical Equipment

Arguably one of the most important considerations when performing microsurgery is the selection of appropriate microsurgical equipment. The optimal setup not only impacts outcomes and success rates, but may permit microsurgeons to improve efficiency and extend the duration of their careers.

52.2.1 Comfort and Ergonomics

Microsurgical procedures vary in duration depending on the specific case performed. While MESA and varicocele procedures may last less than an hour, VR can take 4 hours or more. The case duration therefore has a big influence on the positioning of the surgeon during the case.

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Surgeons may elect to stand for shorter cases and sit for ones lasting over an hour. The specific seat selection is often challenging, as seats with rollers may slide away from the operative position, and specialized surgical beds may be required to allow neutral placement of the surgeon's lower extremities without requiring body contortion. Additionally, the presence or extent of a physical tremor may necessitate adjunctive supports such as arm rests during a case. Each of these factors should ideally be optimized to provide a stable platform upon which the procedure may be performed.

The importance of ergonomics goes beyond simple surgeon comfort. An increasing amount of research is available on the impact of posture and positioning during microsurgical procedures on overall surgeon musculoskeletal health [31]. Prolonged periods of neck strain may lead to chronic pain conditions and shorten an otherwise long-term surgical career. This may be further exacerbated by the utilization of loops or other head appliances rather than a free-standing operating microscope. Given the risks of static posturing and persistent neck flexion, whenever possible, neutral spinal positions should be achieved, and periodic breaks should be performed to rest and stretch the neck muscles.

52.2.2 Instruments

Several brands of microsurgical instruments are available for purchase and may be utilized interchangeably during various microsurgical procedures. Arguably the three most important instruments are the needle driver, pickups, and micro-scissors. The needle driver should ideally be non-locking and should have a slight curve to the distal tip, while pickups should be available both with and without teeth. The micro-scissors should ideally be saved for fine dissection, incising epididymal tubules, and only be used to cut fine sutures such as 9-0 and 10-0's.

Micro-instruments also require extra care with handling and processing. When placed in instrument trays, rubber protective tips should be used where possible, and the tips should never be

tapped on a hard surface to reposition it in the hand. When damage to fine instruments is identified, the instrument should be repaired promptly to avoid compromising surgical outcomes. Magnetization is also a common issue which can dramatically increase the level of difficulty of a case. This can be easily addressed through the use of a demagnetizer either when needed or with each instrument processing.

One final comment on instruments is that the surgeon should get into a habit of routinely cleaning the instruments between each maneuver. Particularly with microsurgery, small blood clots on instruments can prevent it from grasping suture, impair controlled needle release, pull suture inadvertently, or cause other, avoidable problems.

Specialized equipment may also be helpful with select cases. One such example is with a micro Doppler probe. This instrument is able to detect blood flow in the testicular artery, facilitating varicocelectomy and significantly reducing the likelihood for testicular loss, a complication particularly devastating when performed with cases of infertility.

52.2.3 Optics

The quality of optics is extremely important in microsurgical procedures. This is directly evidenced by comparative outcomes demonstrating lower patency rates for VR among surgeons utilizing loupes compared to an operating microscope [22]. Higher quality optics also typically offer brighter light sources, broader depth and size of field, wider focal ranges, and improved visualization for the surgical assistant, among others. As noted previously, other downsides to utilization of loupes is the additive neck strain, which may result in chronic pain or injury over time [31].

Suture Selection Although suture selection is not critical for MESA, microTESE, or varicocelectomy procedures, it becomes essential during VR procedures. The optimal sutures for VR have not been defined, and to the author's knowledge,

there is currently no literature to suggest improved outcomes with one specific suture over another. The choice of suture will ultimately be up to each surgeon and will be based on various factors. Larger sutures such as 5-0, 6-0, or 7-0 are often used to provide additional strength but are likely too large to be used for the direct mucosal anastomoses. With epididymovasostomies (EV), typically 10-0 or 11-0 sutures are required for the mucosal portion, while stronger sutures are used to secure the adventitia.

The decision on utilizing a tapered versus cutting needle is also left to surgeon discretion, with tapered needles resulting in less trauma but also added difficulty with suture passage. Suture length is also an important consideration, as short sutures will reduce suture tangle but require additional sutures (added expense). Similarly, the use of double-armed needles may permit more directed placement within the mucosal lumen but may also require larger numbers of sutures (added expense). The extent of needle curve is also important to consider, as some surgeons prefer a “fish-hook” curve to aid in mucosal penetration, while others prefer a gentler sway to the needle.

52.3 Microsurgical Procedures

52.3.1 Microscopic Epididymal Sperm Aspiration

52.3.1.1 Indications

Various sperm retrieval procedures have been described, including MESA, percutaneous epididymal sperm aspiration (PESA), testicular sperm extraction (TESE), testicular sperm aspiration (TESA), and microTESE. Each of these procedures are capable of producing sufficient sperm for IVF/ICSI types of assisted techniques in cases of obstructive azoospermia (OA), but not sufficient numbers for intra-uterine insemination. In cases of non-obstructive azoospermia (NOA), MESA, PESA, and TESA procedures should not be used, as they are unlikely able to retrieve sufficient sperm to proceed with assisted techniques.

52.3.1.2 Description of Technique

MESA procedures may be performed in the operating room under general / monitored anesthesia care or in the office under local anesthesia. Following appropriate anesthetic, a scrotal incision is made, and the testicle is either delivered or rotated such that the epididymis becomes visualized. Gross examination of the epididymis will typically demonstrate regions of dilated tubules. The epididymal sheath is next entered as close to the caput as possible at a location of dilated tubules. If the testicle is not delivered, pre-placed stay sutures on each side of the epididymis may assist in stabilizing the tissue and keeping it within the operative field.

The operating microscope is then advanced, and hemostasis is achieved with bipolar cautery. One or more tubules are then carefully transected, and fluid aspirated into syringes prepared with sperm preservation media. Sperm may then be observed under the microscope to assure that motility is present. If not present, other locations (ideally more proximally) should be sampled in the epididymis until motility is encountered. Similarly, if no sperm are seen, other epididymal locations should be sampled. If no sperm are seen despite multiple attempts, a TESE procedure is then performed.

Once sufficient sperm are retrieved, the testicle is returned to its normal anatomic position, and the wound closed.

52.3.1.3 Outcomes

The superiority of one surgical approach (MESA vs. TESE, TESA, PESA) over another remains debatable and is likely dependent on multiple factors, including the etiology and location of obstruction and underlying DNA fragmentation levels. In a study comparing outcomes of MESA vs. TESE, 374 men with OA undergoing ICSI were found to have improved live birth rates (39% vs. 24%), implantation, and clinical pregnancies (OR 1.82) with MESA compared to TESE [53]. It is notable that sperm were retrieved as proximally (caput epididymis) as possible. Additionally, no differences between fresh and frozen specimen were noted on overall outcomes. Similar findings were demonstrated by a second

group, with higher live birth rates noted in cases where sperm were retrieved via MESA [21]. One major confounder with both of these studies was that MESA sperm were utilized preferentially, and TESE performed only in cases where MESA sperm could not be retrieved.

Outcomes are also likely impacted by the overall length of the epididymis (in cases of congenital absence of the vas deferens), with longer epididymides associated with better outcomes [44]. In cases of prior vasectomy, it is unclear if the time since vasectomy impacts live birth rates with MESA and ICSI. In a large series of VR outcomes, Silber and colleagues noted decreased pregnancy rates (20% lower when comparing longest to shortest) by increasing time interval since vasectomy, however, results were not controlled for the type of anastomosis (VV vs. EV) performed [50].

The use of PESA/TESA versus MESA/TESE is also debatable. Common arguments for PESA/TESA include increased availability, lower cost, minimally-invasive nature, and ability to retrieve in the office with local anesthesia and without microsurgical training. In contrast, arguments for MESA/TESE are that it retrieves a cleaner and more voluminous sample, therefore requiring fewer overall procedures and ability to cryopreserve additional specimen. As office-based procedures under local anesthesia are becoming more common, the arguments for PESA/TESA are less valid, and MESA/TESE should likely be considered the gold-standard of care in contemporary practice [2, 5, 12, 39].

52.3.2 Microscopic Testicular Sperm Extraction

52.3.2.1 Indications

MicroTESE represents a relatively newer modification to the standard TESE procedure and is commonly performed in cases of NOA or cryptozoospermia and high DNA fragmentation indices [4, 15]. The specific benefits of microTESE over TESE remain debatable. Meta-analysis in 2014 and 2015 evaluating sperm retrieval in men with

NOA reported higher success rates among microTESE (43–63%; 1.5× more likely than TESE) compared to TESE (17–45%; 2.2× more likely than TESA) and TESA procedures [6, 13]. Similarly, a direct comparison evaluating retrieval rates via TESE from one testicle and microTESE from the other reported 47% success with microTESE vs. 30% with traditional TESE [3]. However, since that time, multiple additional publications from other surgical centers have identified lower retrieval rates with microTESE (41–44%) compared to initial reports, suggesting that the true benefits may be isolated to select subpopulations and less significant than initially publicized [8, 11, 25].

52.3.2.2 Description of Technique

A microTESE is performed similar to the more traditional TESE procedure. Following anesthesia, a midline, paramedian, or transverse scrotal incision is made, and the testicle is delivered through the wound. The apices of the tunica vaginalis are tagged to assist with later testicular replacement into the scrotum. Once the testicle is delivered, either a hemi circumferential or longitudinal incision is made into the testicle on the side opposite the epididymis, and the testicle opened in a clamshell fashion.

At this point, the operating microscope is brought into the field, and the testicle assessed. The overall pattern of the seminiferous tubules should be compared to identify any dilated tubular regions. Heterogenous appearing and dilated tubules are more likely to result in successful sperm retrieval when compared to a more homogeneous appearing tubular structure [8]. Similarly, men with Klinefelter syndrome often exhibit signs of Leydig cell hyperplasia, which may be falsely interpreted as dilated seminiferous tubules.

After an initial evaluation, dilated tubules are dissected and placed into sperm preservation media. The testicle is then gently dissected in a systematic fashion with care taken to avoid complete devascularization of segments of seminiferous tubules. This is continued for a preset amount of time, or until sufficient sperm are identified.

Periodically, the sampled regions may be assessed for the presence of sperm by mechanically disrupting the tissue with scissors and repeatedly aspirating and expulsing the fluid within the sperm preservation media. A small sample is then placed on a calibrated slide, and the slide examined for the presence of sperm. Given the improved optics of the tabletop microscopes in the OR compared to those used for ICSI, it is not uncommon to find sperm in the OR setting and subsequently be unable to identify it at the time of ICSI.

If no sperm are visualized after dissection of one testicle, sperm may be identified on the contralateral testicle in an estimated 8% of cases [47]. The decision as to whether or not to proceed with the contralateral testicle should ideally be discussed with the patient prior to the surgery, given the added morbidity associated with bilateral dissection.

Once dissection is complete, the testicle is thoroughly irrigated and reapproximated using either interrupted sutures or clamps. The testicle is then closed using either absorbable or non-absorbable suture. Following closure, the testicle is returned to its normal anatomic position by pulling on the previously placed tunical apical clamps until the testicle is relocated inside the tunica vaginalis. The tunica is then closed, and the testicle fully replaced within the scrotum.

52.3.2.3 Outcomes

The overall likelihood of achieving a successful live birth among men with NOA undergoing microTESE is variably estimated and ranging from 13–22% [14, 28, 54, 55]. In cases where sperm are successfully retrieved, fertilization and pregnancy outcomes are lower among men with NOA compared to OA and those using donor sperm with ICSI [36, 57]. Of men who had previously undergone a negative TESE, microTESE was subsequently able to identify sperm in 15% of cases [24]. To our knowledge, no authors have reported on the success rate of repeat microTESE after an initial failed microTESE procedure.

52.3.3 Varicocelectomy

52.3.3.1 Indications

Varicocelectomy has been proposed for several indications, including testicular pain, ipsilateral testicular atrophy in adolescents, abnormal semen analysis (exception for isolated teratospermia), and sub/infertility [46]. Other proposed indications which remain controversial include for the improvement of testosterone levels, revision of prior varicocelectomies, concomitant contralateral subclinical varicoceles, to improve elevated DNA fragmentation, or among men with idiopathic infertility or azoospermia [1, 9, 30, 48, 51]. Varicocelectomies are graded on a scale of 0–3, ranging from identified on ultrasound only (subclinical – grade 0), palpable with Valsalva (grade 1), palpable without Valsalva (grade 2), and grossly visible (grade 3). The surgical management of grade 0 varicoceles is broadly recognized as unnecessary and inappropriate while grades 1–3 are valid pathologies ([29]; Practice Committee of the American Society for Reproductive et al. 2014).

Several different techniques to manage varicoceles have been described, including embolization, laparoscopic ligation, inguinal, and subinguinal with or without microscopic assistance, among others. In comparing outcomes, several meta-analyses have consistently demonstrated optimal outcomes with both the microscopic inguinal and subinguinal approaches, with improved pregnancy rates, semen parameters, and lowest complication rates compared to other techniques [10, 56].

52.3.3.2 Description of Technique: Microscopic Inguinal/Subinguinal Varicocelectomy

Following general and/or local anesthesia, an incision is made either in the inguinal (approximately 1/3 to 1/2 the distance from the anterior superior iliac spine to the pubic symphysis) or subinguinal (approximately 1–2 cm cephalad and lateral to the lateral border of the proximal penile shaft) region. Dissection is carried down to the level of the testicular cord. For inguinal

approaches, the fascia overlying the external inguinal sheath is incised, and the cord exposed. Once isolated, the cord is brought to the skin surface, with care taken to assure that the vas deferens is included with the cord. The cord should ideally not be on tension, to avoid undue compression on the testicular arteries and veins, which may otherwise impair the ability to detect a micro Doppler signal. A Penrose drain or similar instrument is then placed underneath to secure the cord for the remainder of the case. The external cremasteric sheath is then entered, opened longitudinally, and then secured laterally to expose the inner cremasteric sheath.

At this point, the operating microscope is advanced, and a micro Doppler probe is utilized to assess the position and number of vessels that can be identified. The underlying anatomy will vary slightly and usually consists of the vas deferens with deferential vessels, a vein-artery-vein complex, a fatty component, and a separate larger independent packet of veins. Careful and methodical dissection is then performed to ligate all visualized veins while working to keep the lymphatics, vas deferens, and arterial vessels undisturbed. Larger vessels are typically ligated with either permanent ties (silk commonly used) or titanium clips, and the micro Doppler is utilized prior to the ligation of vessels to assure that the testicular artery remains unaffected.

Although specific techniques vary, one approach to the varicocelelectomy is to start with a leading edge of the inner cremasteric sheath and continually transect all structures circumferentially that are not lymphatics, vas, or arteries. This approach results in dissection of all structures prior to reaching the main vein-artery-vein complex. As this structure is often the most difficult to dissect, this facilitates exposure to reduce the potential for accidental injury to the testicular artery.

Once all veins have been ligated and the testicular artery uninjured, the cremasteric and deferential packets are examined with additional veins ligated as needed. The testicular cord is then returned to its normal anatomic position, the external inguinal sheath sutured (if applicable), and the wound closed.

52.3.3.3 Outcomes

Varicocelelectomy outcomes are often difficult to interpret given the heterogeneity of cohorts, lack of definitive methodology to clearly and consistently identify Grade 1 varicoceles, differing techniques utilized, and confounding nature of couple factors in fertility measures. As noted previously, microscopic inguinal and subinguinal varicocelelectomy have been shown to have superior outcomes to other approaches, with a number needed to treat to achieve a pregnancy estimated to be 7 for men with abnormal semen parameters and 17 for those with normospermia [30]. Predictive algorithms have also been proposed to identify the impact of varicocelelectomy on various semen parameters [49].

Among men with NOA, varicocelelectomy has been shown to improve the rate of return of sperm to the ejaculate in a small percentage of men, reduce DNA fragmentation, and has variably reported impacts on assisted reproductive outcomes [17, 19, 43, 48, 51].

52.3.4 Vasectomy Reversal

52.3.4.1 Indications

The specific indications for VR are somewhat debatable, and opinions tend to vary by specialty. The American Society for Reproductive Medicine provided a practice document, last updated in 2008, which states that clinicians should consider factors including female partner age and fertility when deciding on whether or not to pursue a VR [45]. Other factors which should be considered when deciding between VR and IVF/ICSI include the number of children desired, total costs, specific success rates of the VR surgeon or IVF clinic, duration since vasectomy, rates of multiple gestation, potential for chromosomal abnormalities and subsequent care required, diminished ovarian reserve, and couple preferences.

In cases where VR is sought for reasons other than fertility (psychological factors / pain), very little data exist on anticipated success rates. A small, retrospective study of 13 men who developed post vasectomy pain (mean time to onset 2 years post vasectomy) reported that 69%

remained pain free post-operatively at a mean of one and a half years post VR.

As with other microsurgeries, each surgeon utilizes minor personalized modifications of standard VR steps. Very limited data are available suggesting a benefit of one specific technique over another. One study comparing outcomes of VR performed with loupes versus an operating microscope demonstrated longer operative times and improved success rates (96% vs. 72% patency) with the operating microscope [22]. Several other studies have compared the traditional two-layer anastomosis with a modified one-layer technique [20, 40]. In a meta-analysis of three manuscripts, Herrel and colleagues concluded that there were no significant differences between techniques [20].

52.3.4.2 Description of Technique

VR is commonly performed in operative-suite or office-based settings, although the far majority of office-based practices perform only vasovasostomies (VV). Office-based EV procedures have been recently described, however, with similar outcomes compared to those performed under general anesthesia [2]. Following anesthesia (local, monitored, or general), a midline scrotal or paired, paramidline vertical incisions are made near the penoscrotal junction. The vas deferens is dissected and brought through the incision, and the prior vasectomy site is identified. Care is taken during the dissection to avoid injury to the deferential vessels, and the vas is dissected adequately to allow for a tension-free anastomosis. In cases of a large absent vasal segment, some surgeons elect to deliver and rotate the testicle and dissect the membrane between the convoluted vas and epididymis. This maneuver can provide an additional 2–4 cm length of vas.

Once the vas has been fully dissected, it is incised on the testicular end and sampled. Some surgeons elect to utilize an 11-blade while others utilize specific vas graspers (straight or angled) and a straight microblade. Although there remains some debate on the optimal decision process, the presence of sperm or sperm parts indicates that a VV may be performed. In the absence of sperm, an EV is appropriate, with the possible exception

of cases where voluminous clear fluid is encountered with no sperm present. The abdominal portion of the vas above the prior vasectomy site is then transected, and instillation of fluid into the abdominal vas is performed to rule out other sites of obstruction.

52.3.4.3 Vasovasostomy

The abdominal and testicular vasal segments are re-approximated using either interrupted sutures or vas grasping clamps. Ideally, the deferential vessels should also be aligned. The surgical field is then prepared, with some electing to utilize a Penrose or similar drain behind the vas and white towels draped around the operative site. The objective is to prevent suture from being inadvertently entrapped during the remainder of the microsurgical portions of the case and stabilize the vas for re-anastomosis. At this point, either a single-modified or double-layer anastomosis is performed. For the double-layer anastomosis, some surgeons elect to place the inner, mucosal layer sutures first, while others prefer to place 1–2 backwall sutures to provide support prior to the mucosal layer. Typically, the mucosal layer sutures are either 10–0 or 9–0, while the adventitial layer stitches may be 7–0, 8–0, or 9–0. Five to six mucosal sutures are then placed, with many surgeons electing to pre-mark the target sites with a fine surgical marker to prevent large gaps from forming. The final three sutures are often placed primarily and then tied once it is assured that the sutures are not tangled or back-walled. Once the mucosal layer is complete, additional support, adventitial sutures are then placed circumferentially. In the case of a modified single layer, 9–0 suture is placed transmurally in at least four quadrants followed by additional adventitial sutures [40]. At this point, many surgeons elect to place additional support sutures into the perivasal tissue to alleviate potential strain on the newly formed anastomosis.

52.3.4.4 Epididymovasostomy

Following a decision to proceed with epididymovasostomy, the tunica vaginalis is incised over a region of approximately 2/3 of the length of the sac and testicle delivered. Care is taken to avoid

over dissecting the tunica, both because the vas deferens will need to be relocated through the tunica and to facilitate replacement of the testicle into the scrotum following anastomotic completion. At this point, the abdominal vas deferens is passed into the tunica from a posterior, cephalad position. The vas is then secured to the tunica to provide support and prevent undue traction on the future EV anastomosis.

The epididymis is then examined grossly to identify regions of dilated tubules. Ideally, it is preferred to anastomose to the most distal epididymal segment possible while still assuring the presence of sperm (to allow for natural maturation of sperm). Most often, this results in an anastomosis near the mid portion or caput epididymis. In cases where additional length is required, the epididymal tail can be dissected off of the testicle and reflected cephalad. Once an appropriate location has been identified, some surgeons will elect to further secure the peri-vasal tissue to the testicle and loop the vas back to the epididymis.

At this point, the microscope is advanced, and a small region of the epididymal sheath is incised. Careful dissection is then performed to avoid inadvertent entry into an epididymal tubule. If punctured, it is preferred to move to a site more proximal and bipolar to the ruptured region. Once an appropriate tubule is identified, some surgeons elect to secure the adventitia of the vas to the epididymal sheath at the 12 o'clock position using a 7-0, 8-0, or 9-0 suture. Parallel double-armed 10-0 sutures are then passed into the epididymal tubule, with the sutures left in the tubule. The tubule is then incised and fluid sampled. If no sperm are seen, a separate location will need to be selected, and the preceding steps repeated. If sperm are visualized, however, the sutures are then pulled through the epididymal tubule. Sutures are then placed in four quadrants full-thickness from the vasal mucosa to the adventitia, with the tubule appropriately aligned. Once placed, some surgeons elect to place an additional six o'clock suture from the vasal adventitia to the epididymal sheath prior to tying the 10-0 sutures in an attempt to prevent pulling through of the suture. The 10-0's are then tied, and additional support

sutures are placed to secure the vas to the epididymal sheath.

Once the anastomosis is completed, the testicle is returned inside of the tunica vaginalis, and the tunica sutured closed. The testicle is then replaced into the scrotum.

52.3.4.5 Outcomes

The success of the VR is dependent on several factors, including the time since vasectomy, ability to perform VV on one or both sides, female partner age and fertility status, presence of a sperm granuloma, different partner, prior pregnancy, vasal clips, and surgeon experience/technique, among others [7, 37, 38, 50].

It is notable that although patency rates slowly decline and ultimately stabilize based on time since vasectomy, the total motile sperm counts and pregnancy rates continue to exhibit time-dependent linear declines [37, 50]. The definition for success or patency is also variably defined, with an approximate 20% difference noted between the loosest (1 sperm seen in the ejaculate at any time point) and most strict definition (completely normal semen analysis) [2]. Pregnancy rates also lag behind patency rates, and the median time to achieve a pregnancy after VR is estimated at 17 months [35]. Interestingly, semen parameters predictive of pregnancy post VR are lower than in studies of couples with infertility [18, 32]. Specifically, total motile counts >five million are associated with a 71% change of pregnancy, which is similar to those with >20 million (69% pregnancy rate), while those with <five million have a 28% overall chance of subsequent pregnancy.

52.4 Role for Robotics

Robotic-assisted microsurgery for male infertility has been reported for microTESE, varicocelectomy, and vasectomy reversals [41, 42]. Although limited data are available, overall patency rates with the robotic approach are similar to non-robotic series [26, 33, 42]. The overall need and utility of robotic-assisted platforms remains debatable, with arguments suggesting improved

surgeon comfort with the robotic approach at the possible expense of operative time and cost. However, robotic-assisted platforms have a clear role and indication in select scenarios, such as with vasal obstruction at the level of the inguinal canal requiring intracorporeal vasoplasty [52]. Although the debate regarding robotics may change with ongoing advances in technology, at the present time, its use remains at the discretion of patients and providers, without clear inferiority or superiority to traditional techniques.

52.5 Office-Based Practice

Over the past few years, there has been renewed interest on finding more cost-effective, office-based approaches to various surgical procedures, including those performed for male infertility. The emphasis has been influenced by multiple variables, including an industry-wide drive towards value (similar outcomes with lower cost), patient desires to avoid anesthesia, enhanced surgical techniques, and improved efficiencies and conveniences gained with an office-based approach. Although some procedures including TESE, MESA, varicocelectomy, and VV had previously been described, more recent publications have added microTESE and VE, suggesting that all male fertility microsurgery can successfully be performed in an office-based setting without general or monitored anesthesia [2, 16, 23, 27, 39].

The logistics of transitioning to an office based practice for male fertility have been described by Alom and colleagues [2]. Beyond establishing an office setting with all necessary operative equipment (microscope, surgical bed, lighting), arguably the most important aspect is developing a skillset to achieve complete anesthesia with local blocks alone. Several principles to achieving appropriate local anesthesia include judicious, targeted use of anesthetic, selection of a long-acting agent, and achieving the right degree of dilution to balance available volume and efficacy. Additionally, minor modifications to technique and increased surgeon self-awareness may be required to assure patient comfort.

Outcomes of office-based vs. traditional OR-based male fertility microsurgery have been evaluated in a series of 68 men undergoing the procedures in-office [2]. Results demonstrated that all cases were successfully completed with no differences in operative time, rate of adverse events, or post-operative outcomes. The overall costs of the procedures were significantly reduced from 50–89% compared to those performed in an OR setting. Given the cash-pay nature of many infertility procedures, the significant cost savings both open up the possibility of treatment for many individuals and re-open the cost/benefit debate between VR and IVF/ICSI. From a patient preference standpoint, when given the option of selecting the office versus OR setting for the procedure, 86% of patients chose the office setting.

52.6 Conclusions

Microsurgical procedures are a mainstay of contemporary management for male-factor infertility. Although many of the techniques themselves have changed little over the past several decades, advances in technology and scientific research have altered the indications for surgery and given rise to new techniques. The surgical indications and technical steps were reviewed for MESA, microTESE, varicocelectomy, and VR, and outcomes were discussed in the context of male-factor infertility. Specifically, MESA may represent a superior technique for sperm retrieval in cases of OA/ICSI, while microTESE likely achieves a higher sperm retrieval rate in OA compared to TESE. Varicocelectomy has demonstrated benefits in nearly all scenarios of infertility, while VR demonstrates excellent long-term outcomes in appropriately selected individuals. Although robotic assistance remains a controversial topic for use with microsurgical infertility procedures, it is likely uniquely suited to address the rare case of bilateral inguinal vasal obstruction. And finally, the prevalence of office-based male fertility procedures will likely continue to expand, given a desire for maintaining efficacy in a cost-conscious atmosphere.

Key Summary Points

- Obtain and properly maintain specialized micro-surgical surgical equipment with frequent intra-operative cleaning to optimize outcomes.
- Focus on surgeon ergonomics to facilitate outcomes and avoid chronic musculoskeletal injury.
- Sperm extraction techniques vary, with similar success rates depending on surgeon level of comfort with each procedure. MESA carries a slightly higher success rate but may have slightly higher cost in some practices.
- MicroTESE may have a slight retrieval advantage in certain clinical sub-populations. Bilateral approaches yield improved results in only 8% of cases.
- Subinguinal microscopic assisted varicocelectomy yields the best results with lowest complication rate for varicocele Grades 1-3. The use of microvascular Doppler is highly recommended.
- Vasectomy reversal should be performed with a repeatable systematic approach. Our group has been able to successfully perform both VV and VE in the office setting with high success rates at a greatly decreased cost. Our suture modification for VE has greatly improved our success rates.
- Robotic assisted microsurgery remains at the discretion of patients and providers, without clear inferiority or superiority to traditional techniques.

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Surgical Reconstruction of Penile Fractures: Impact on Voiding and Sexual Function

53

Steven B. Brandes and Shyam Sukumar

53.1 Introduction

Penile fracture is a relatively uncommon urological emergency. It may have been first described by Abu-Al-Qasim (Latin: Albucasis), one of Spain's greatest medieval surgeons, over a thousand years ago [1, 2]. However there continues to be a paucity of data on the incidence of this condition. In a national weighted sample of patients from 2006 to 2007, 1043 men were admitted with a diagnosis of penile fracture with a mean age of 37 and over-representation of African American and Hispanic patients. Concomitant urethral injury was noted in 21% of patients. The average total charges per patient was \$13,000 [3]. While non-operative management was considered a reasonable option in the past, the high incidence of side effects has led to surgical repair now being considered the gold standard. The long-term sequelae of penile fracture include erectile dysfunction, voiding dysfunction and penile curvature.

53.2 Penile Anatomy and Pathophysiology

The human penis consists of paired corpora cavernosa and the corpus spongiosum. The tunica albuginea is a firm fibrous layer enveloping each corpora cavernosa and the urethra. Buck's fascia covers all of these layers. If Buck's fascia remains intact during a penile fracture, then the hematoma is limited to the penis but if it is disrupted then a 'butterfly' hematoma limited by Colle's fascia results.

The tunica albuginea is a two layered structure consisting of an interspersing network of collagen and elastic fibers and is arranged as an outer longitudinal and inner circular layer. The elastic fibers serve to prevent excessive stretching of the collagen network and thereby prevent corporal rupture until intracavernous pressures reach 1500 mmHg. The other critical feature that helps mitigate the risk of penile fracture is the nature of the intracavernous tissue, which is composed of muscle and connective tissue.

Rose et al. [4] performed histological evaluations on samples of tunica albuginea obtained away from the site of injury in patients undergoing surgical repair for penile fracture. They also compared these samples to samples obtained from patients undergoing surgery for other indications. Structural anomalies of the tunica were noted in 83% of patients with penile fracture, compared to no abnormalities seen in the control

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group. These histological abnormalities were of a chronic inflammatory nature and they hypothesized that such structural alterations likely weakened the tunica albuginea (as a first ‘hit’) and with subsequent trauma (second ‘hit’) penile fracture resulted.

Most penile fractures are transverse, unilateral and situated on the ventral surface of the penile base. The anatomical explanation for the ventral distribution is that there is an attenuation of the outer layer fibers of the tunica between five and seven o’clock positions rendering this location particularly vulnerable [5]. In a series of 300 patients from Tunisia, 60% of the fractures were noted to be in the right corpora. The proximal-distal distribution was as follows: 54%, 20% and 26% in the proximal, mid and distal locations, respectively [6]. Up to 14% of injuries can be bilateral and a high degree of suspicion for urethral injury is required in these instances [7, 8].

53.3 Etiology of Penile Fracture

53.3.1 Penile Fracture

The predominant mechanism of penile fracture varies by geographic location and local cultural practices.

In a large meta-analysis of the literature of penile fractures, Amer et al. reported that 46% were caused by sexual intercourse, 21% by forced flexion and 18% by masturbation [9].

The highest reported case series numbers of penile fracture are from the Islamic Middle east. Some reports have found that just over 50% of cases reported worldwide occurred in the Islamic Mediterranean countries [6, 10]. Two of the largest series of penile fractures include a Tunisian report [6] of 300 penile fractures over 30 years and an Iranian report [11] of 352 patients over 18 years. A substantial number of injuries in North Africa and the Middle East are caused by the practice of forced manipulation to achieve detumescence called *taqaandan*. In the large Iranian series from Kermanshah detailing their

experience over 18 years, *taqaandan* (from the Kurdish for ‘to click’) accounted for 76% of cases [11].

In a systematic review that focused more on European series, sexual intercourse accounted for 80% of cases [12]. The mechanism involves the penis sliding out during intercourse and striking the female pelvis forcefully. This is felt to be more likely with the reverse coital position where the male partner takes the more dependent position during intercourse.

Other rare causes that have been reported in the literature [9] include striking a toilet seat, masturbation aided by a vacuum cleaner [7] and being kicked by a cow [13]. In some parts of the West Indies, the practice of “dagging” is a significant cause of penile fracture. This practice describes the act of men vigorously thrusting their tumescent penises against women in certain clubs and has apparently grown out of the dance-hall music culture in this part of the world. This has become enough of an issue to the point where music that is suggestive and encourages such practices has been prohibited by the Broadcasting Commission of Jamaica [14].

53.4 Clinical Features and Imaging

The diagnosis of a true penile fracture is usually obvious on clinical evaluation. Thus imaging is typically not necessary [15]. If there is a high suspicion of a penile fracture based on clinical findings, operative exploration should be undertaken. A concomitant urethral injury can be ruled out preoperatively using a retrograde urethrogram or cystoscopy.

A thorough history and physical exam is important to diagnose a penile fracture. The usual symptoms are a ‘popping’ or ‘cracking’ sound accompanied by severe penile pain and detumescence [16, 17]. On exam, gross swelling and penile hematoma is noted (eggplant sign) if Buck’s fascia remains intact. A ‘rolling’ sign can be noted by sliding the skin over the site of injury where a tunical defect or clot will be evident.



Fig. 53.1 Transverse penile fracture and associated near-total transection of the corpus spongiosum and urethra. (Image courtesy of Brandes [41]. Reprinted with permission from Nova Science Publishers)

If Buck's fascia is injured then a 'butterfly' hematoma limited by Colle's fascia is evident [1]. Up to 38% of penile fractures can be associated with a urethral injury (see Fig. 53.1). Bilateral corporal injuries are particularly associated with urethral involvement (see Fig. 53.2). Dorsal vein injuries can mimic a true penile fracture but the swelling is more symmetrical and patients can lack the typical presenting symptoms of a fracture (see Fig. 53.3).

Some authors believe that preoperative imaging may be a useful adjunct. The British Association of Urological Surgeons consensus statement on penile fracture states that ultrasonography can be confirmatory and locate the exact site of the tear, which may aid in surgical planning [18]. In cases of diagnostic uncertainty penile MRI has been advocated [19, 20]. Fedel et al. [20] reported that of all the available imaging modalities, only MRI reliably diagnosed penile fracture in equivocal cases. Most authori-



Fig. 53.2 Bilateral penile fracture and near-total transection of the urethra. (Image courtesy of Brandes [41]. Reprinted with permission from Nova Science Publishers)

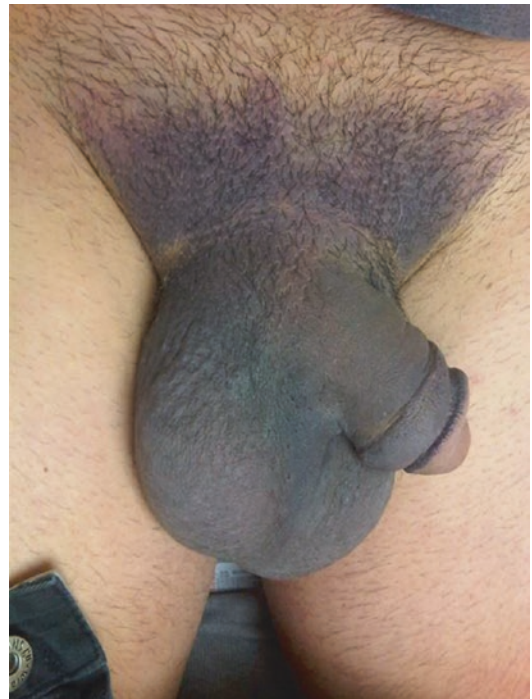


Fig. 53.3 Injury to the dorsal vein with symmetric ecchymosis of the penis and scrotum after intercourse. (Image courtesy of Brandes [41]. Reprinted with permission from Nova Science Publishers)

ties however continue to believe that penile fracture is a clinical diagnosis and operative exploration needs to be undertaken if suspected based on clinical findings alone.

53.5 Treatment and Management

53.5.1 Nonoperative Management

Penile fractures have traditionally been treated non-operatively [21]. A variety of treatments have been described, including sedative medications, cold compresses, compression dressings, fibrinolytic therapies and anti-inflammatory regimens [21, 22]. Regardless of the specific non-operative modality, the disruption in the tunica albuginea was left to recover by secondary intention. There is a high rate of variance in the reported adverse effects for conservative management with short term reports detailing rates of less than 10–20%. Data from robust pooled meta-analyses however indicate that the total rate of adverse effects after conservative treatment is about 46%, including erectile dysfunction in 22%, plaques/nodules in 19%, curvature in 13% and pain in 5% [9].

53.5.2 Immediate Surgical Repair

The first surgical repair for penile fracture was reported in 1936 by Theodore Fetter and Edward Gartman, a staff physician and resident, respectively, at Jefferson Medical College [23]. Nevertheless, surgical management only became standard of care after reports on comparative outcomes were published in the 1980s [22, 24, 25]. Surgical management has a much lower reported rate of total complications of 20% vs. 46% for non-operative management. Adverse events include erectile dysfunction in 1.9%, plaques/nodules in 14%, curvature in 3% and pain in 1% [9].

Informed consent and thorough preoperative counseling is paramount, specifically emphasizing that postoperative erectile dysfunction is consequent to the injury and not the surgical repair per se. Our operative approach involves a degloving incision for full exposure of the corpora and a tourniquet at the base of the penis to facilitate hemostasis and thus visualization of the injury. In cases where the tunical injury is not apparent a Gittes test can help identify the injury site by

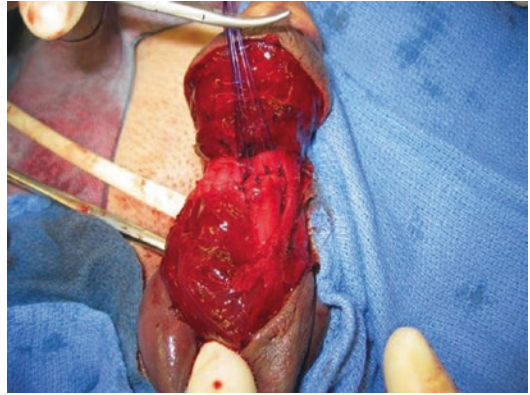


Fig. 53.4 Total transection of the urethra repaired by anastomotic urethroplasty with 4–0 Vicryl sutures. (Image courtesy of Brandes [41]. Reprinted with permission from Nova Science Publishers)

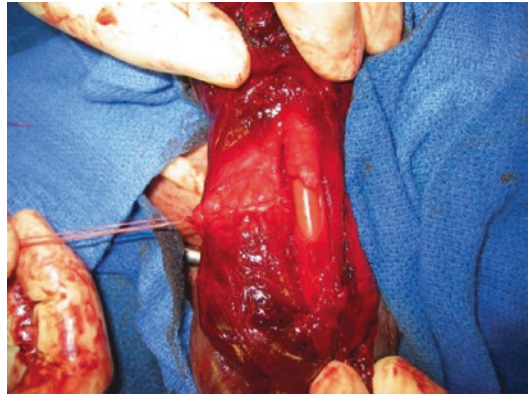


Fig. 53.5 Repair of the right tunica albuginea with running 2–0 Vicryl sutures. Note near-total transection of urethra. (Image courtesy of Brandes [41]. Reprinted with permission from Nova Science Publishers)

extravasation of injected saline [26]. Urethral transection injuries require adequate urethral mobilization for an anastomotic urethroplasty using interrupted 4–0 Vicryl sutures (see Fig. 53.4). Corporal injuries are repaired using running 2–0 Vicryl suture (see Fig. 53.5).

53.5.3 Delayed Surgical Repair

While many authorities regard immediate repair as the gold standard in the management of penile fractures, some groups have reported on outcomes of delayed surgical repair. Nasser and

Table 53.1 Long-term effects on sexual function

Series	Number of patients	Follow-up (months), mean	Normal, % (IIEF >22)	Mild-moderate ED, % (IIEF 12–16)	Severe ED, % (IIEF <12)	Penile curvature, %
Nason et al. [34]	21	46	83%	6%	6%	NA
Kozacioglu et al. [35]	54	45	77%	23%	0	4%
Rivas et al. [36]	27	29	95%	0	5%	27%
Yamacake et al. [37]	42	15	89%	0	11%	11%
Tijani et al. [38]	21	10	100%	0	0	NA
Phillips et al. [39]	39	9	95%	5%	0%	NA

Mostafa reported their series of 24 patients who presented with a penile fracture and underwent conservative management for the first seven to 12 days and then underwent surgical repair under local anesthesia thereafter [27]. The only reported complication was penile deviation in one patient. No erectile dysfunction or voiding difficulty was noted at 6 month follow up. Wong et al. performed a systematic review and meta-analysis of 12 studies evaluating delayed (>24 h) vs. immediate surgical repair (<24 h) [28]. The mean time to surgery ranged from 29 h to 16 days in the delayed group. At a mean follow up of 17 months, there was no difference between groups in terms of erectile dysfunction or penile plaque formation but penile curvature was less common in the immediate repair group (odds ratio: 0.33). The authors noted that none of the patients with penile curvature had sexual dysfunction and the curvature was therefore felt to be clinically insignificant. In conclusion, there does not seem to be any significant long-term complications in select patients who undergo delayed surgical repair. It is important to note that urethral injury would be a contraindication for delayed repair.

tion occurred in 2% of patients, curvature in 3% and plaques in 14% [9]. In a systematic review of the most contemporary series (2012–2017) with a mean follow up of 21 months, Falcone et al. reported the following rates for erectile dysfunction: mild to moderate ED in 12% (IIEF 12–16), severe ED in 9% (IIEF <12), and penile curvature in 16% [12]. Table 53.1 shows the rates of sexual dysfunction in the various published series where follow up was >6 months.

Several single institution series detailing the long-term outcomes after repair of penile fractures are also available. Raheem et al. reported on 11 patients who underwent immediate surgical repair of a penile fracture; 9% of patients experienced mild to moderate erectile dysfunction at a mean follow up of 73 months [29]. In Zargooshi's large series from Iran ($n = 373$, mean follow up of 94 months), 98.6% of men "who had partners" were potent with a mean IIEF score of 29.8 and 94% of patients had an asymptomatic penile nodule [11].

Mechanistically, veno-occlusive dysfunction of the corpora is felt to be the cause of erectile dysfunction after penile fracture but the psychological sequelae are also a significant factor [30]. After a penile fracture, some patients fear re-fracturing the penis. However, as expected, this concern decreases with increasing time from the date of the inciting event [31].

53.6 Long-Term Effects on Sexual Function and voiding function

53.6.1 Effect on Sexual Function

While operative repair reduces the risk of adverse sexual sequelae of penile fractures, up to 21% of patients can still have long term sexual side effects. In a recent meta-analysis of long term sequelae, Amer et al. noted that erectile dysfunction

53.6.2 Effect on Voiding Function

The data for long term effects of penile fractures on voiding function is sparse. Falcone et al. reported that voiding symptoms occurred in 10%, and urethral stricture occurred in 3%, at a mean

Table 53.2 Long-term effects on voiding function

Series	Number of patients	Follow-up (months), mean	Voiding symptoms, %	Urethral stricture, % (total number of patients with urethral injury at initial presentation is presented in parentheses)
Nason et al. [34]	21	46	0	0 (Out of 2 patients with urethral injury)
Kozacioglu et al. [35]	54	45	NA	NA
Rivas et al. [36]	27	29	NA	0 (2)
Yamacake et al. [37]	42	15	NA	0 (5)
Tijani et al. [38]	21	10	0	0 (1)
Phillips et al. [39]	39	9	NA	25% (4)
De Luca et al. [40]	76	3	3%	9.5% (21)

follow up of 21 months [12]. But these data included all patients with penile fractures: with and without an associated urethral injury. If we restricted the analyses to patients who had a urethral injury at presentation, the risk of long term urethral stricture is about 8.6%. Table 53.2 shows the rates of voiding dysfunction and urethral strictures in the various published series, with a special emphasis on long-term outcomes.

Individual single center series have reported similar results. El Assmy et al. reported on long term outcomes of 12 Egyptian patients presenting with penile fracture and concomitant urethral injury managed with surgical repair [32]. At a mean follow up of 90 months, none of the patients had voiding dysfunction except one patient with a urethral stricture (8.3%). Barros et al. reported on a Brazilian series of 27 patients with similar presentation, of whom 15% experienced complications of urethrocutaneous fistula and abscess after urethroplasty [33]. Derouiche et al. reported on a series of 10 patients from Tunisia, none of whom experienced long term urethral or voiding complications after urethral repair [17]. These series confirm the low long-term risk of urethroplasty in patients presenting with concomitant urethral injury.

53.7 Conclusion

Penile fracture is a rare urological condition. A thorough history and detailed physical exam are the cornerstone of diagnosis. Imaging studies are rarely needed. Operative repair is the gold standard for management. Long term effects on

sexual function include erectile dysfunction, palpable nodularity and penile curvature. The main long term adverse effect on voiding function is development of urethral stricture. Most studies on the management of penile fracture are retrospective and use non-validated outcome measures. There is a need for more robust prospective studies and randomized control trials to help clarify the long-term effects on sexual and voiding function.

Key Summary Points

- Penile fracture is a relatively uncommon urologic emergency.
- Urethral rupture must be suspected in any case of penile fracture presenting with bloody urethral discharge. The urethral injury is often partial and localized at the level of the corpora tear.
- Retrograde urethrography is advocated in any case of suspected penile fracture that presents with voiding difficulty, hematuria, or blood at the meatus.
- Although uncommon, voiding symptoms are indicative of a potential urethral injury and therefore warrant investigation. Microscopic hematuria can be indicative of an occult urethral injury.
- Retrograde urethrography is advocated whenever penile fracture is suspected and presents with voiding difficulty, hematuria, or blood at the meatus.

- Current treatment recommendations for penile fractures are for immediate surgical exploration and repair with evacuation of the hematoma, identification of the tunica injury, local corpora debridement, closure of the tunica lacerations, closure of urethral tears, and ligation of any disrupted vasculature.
- Management of urethral injuries is highly variable: for partial urethral tears, treatment options include urethral catheterization, primary closure with nonabsorbable suture, or suprapubic cystostomy tube. Complete urethral injuries can be managed with primary reanastomosis, graft interposition, or stenting over a urethral catheter.
- Long-term complications after penile fracture repair may include: penile deviation, painful intercourse, painful erection, erectile dysfunction, priapism, skin necrosis, arteriovenous fistula, urethrocavernous fistula, and urethral stricture.
- Follow-up is recommended to identify postoperative urethral strictures and erectile sequelae.
- Penile fracture managed within a short time frame from presentation is associated with preservation of erectile potency and long-term overall sexual satisfaction.

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Management of External Genitalia Gunshot Injuries and Traumatic Avulsions in Civil and Military Conflicts

54

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54.1 Introduction

Penetrating trauma is one of the most serious urologic emergencies. Management depends on accurate and rapid assessment to reduce the morbidity and mortality of affected patients. In this chapter we discuss specific ballistic penetrating trauma to the penis and scrotum in both civilian and military contexts.

54.2 Epidemiology of Penetrating Penile/Scrotal Trauma

The genitourinary tract is injured in ~10% of all trauma, and 60% of these injuries involve the external genitalia [1, 2]. Between 20% and 50% of genital trauma is penetrating [3]. The most common site of traumatic GU injury is the kidney, however significant morbidity and mortality

is still incurred from penile and scrotal trauma [4]. Said differently, penetrating GU trauma accounts for 0.57% of all trauma or 2% of penetrating trauma in large urban U.S. series. The majority (78%) of injuries were to the scrotum [1] with up to 70% of patients presenting with concomitant injuries to other structures [3].

Depending on geographic and demographic variances, gunshot wounds (GSW) comprise between 50% and 90% of penetrating genital injuries [1, 3, 5–7]. More recent, U.S. urban studies are trending toward higher percentages of GSW related penetrating genital trauma. Similarly, in military conflicts GSW remains the primary mechanism of penetrating GU trauma.

The mechanics of GSW which have been extensively studied in military literature, are critical to understanding injury patterns and subsequent appropriate repair approaches [8].

54.3 Wound/Injury Mechanics

Many authors summarize wound characteristics by the velocity of the projectile, treating high velocity wounds (those inflicted by rifles) and low velocity wounds (inflicted by handguns) as distinct in their wound mechanics. This can be an oversimplification. The critical component of injury is the amount of energy transferred by the projectile (bullet) which can vary based on the type of bullet, velocity, and distance travelled.

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For instance, a tumbling bullet from a M16 will have a different injury pattern and likely transfer more energy compared to AK-47, despite the velocity and weight of the AK-47 projectile being higher. Thus, it is more appropriate to discuss low and high energy projectile injuries. For the purposes of this review we will discuss low energy injuries as civilian and high energy as military as this is faithful to the majority of scenarios in which each is encountered. It is critically important, however, to obtain an accurate history (if possible) of the type of weapon and bullet in all circumstances as part of the history and physical examination.

A special case should be noted for shotgun injuries. Generally, shotgun injuries are categorized as low velocity missile, however at close range (i.e., five feet away or less), it can create massive tissue destruction. This is important to assess on initial evaluation. It will likely be clear from the extent of the patients injuries, but the evaluating clinician should be aware that close range, low velocity injuries should be considered high energy due to the large mass of the projectile and associated tissue damage. This might be attributed to its compacted bullet which can act as a single projectile of high mass. Thus these should always be considered high energy injuries.

The two primary types of tissue damage that are applicable to GU trauma are direct tissue damage and cavitation.

54.3.1 Direct Tissue Damage

Direct tissue damage can be divided into three categories. The initial direct blunt/crush injury from the bullet or “prompt damage”, the “permanent wound tract”, and the “extravasation zone”.

1. Prompt Damages: These are the result of the direct crush/blunt injury from the projectile. This accounts for most of the low energy projectile tissue damage as there is minimal cavitation (discussed below) [9, 10].

2. Permanent Wound Tract or Permanent: The permanent wound tract or wound channel is the total area of permanent damage from all projectile effects including ischemia from burn injury, direct crush injury, and cavitation. This is the crucial area of damage and it can be difficult to identify upon initial presentation. This has led to over-debridement, particularly in high energy injuries [11, 12].
3. Extravasation zone: Reversibly damaged tissue. Hallmarked by edema and hemorrhage without “macroscopic evidence of damage” [8].

54.3.2 Cavitation

This phenomena is described with projectiles exceeding 600 m/s and is therefore rarely applicable to handgun injuries. However, this accounts for significant increase in tissue damage during high energy ballistic injury; therefore it is extremely important to assess patients for the mechanism of injury when possible. In the civilian population, this becomes important in higher caliber weapons more typically seen in hunting-related injuries.

54.4 Patient Assessment

Patient history is critically important in the assessment of a patient with genital trauma. Typically, patients may be seen and evaluated by a trauma specialist before a urologist is consulted. It is always important to assess the mechanism of injury, the potential for concomitant injury and prior injuries. More than 2/3 of patients will present with accompanying non-urologic injuries [3, 13, 14]. The mechanism of injury, including caliber of ballistic weapon will also assist in understanding degree of tissue damage.

The physical exam should be a focused on three components. This is summarized in Fig. 54.1.

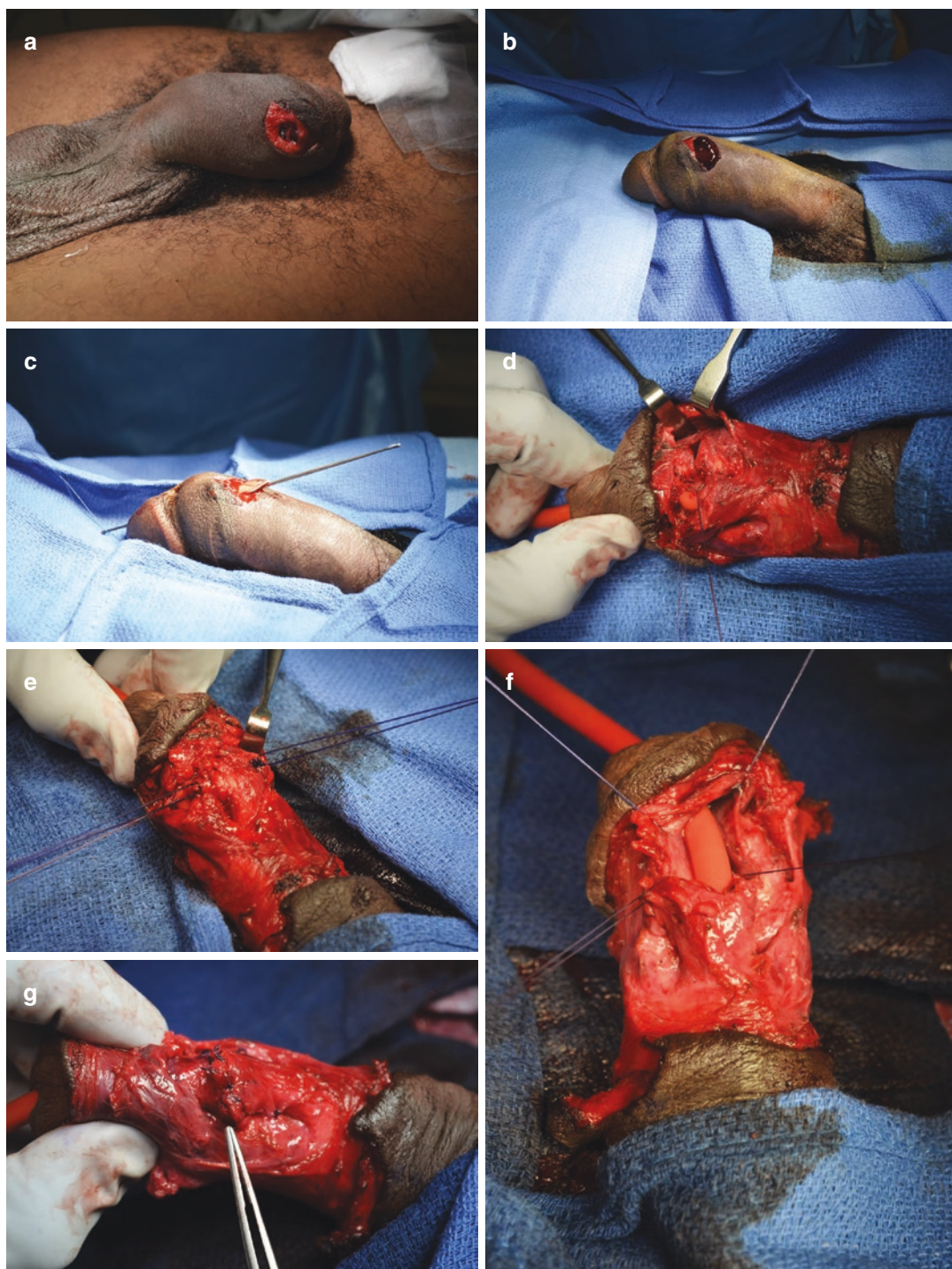


Fig. 54.1 Gunshot Wound to the Penis. Low Velocity. **a.** Exit wound on ventral aspect of penis. **b.** Entry wound on dorsal aspect of penis. **c.** Probe demonstrating trajectory of bullet. **d.** Exposure and Identification of Corporal

Injury (urethral catheter also seen). **e.** Corporal Closure with running absorbable suture. **f.** Exposure of urethral injury with debrided edges. **g.** Urethral Closure in oblique orientation

1. Full examination of all GU structures.
 - a. Suspected urethral injury
 - i. Blood at urethral meatus
 - ii. Voided urine with urine analysis if possible
 - iii. Deciding on catheter placement if possible urethral injury
2. Depth of all penetrating injuries
 - a. Penile – deeper than skin
 - b. Scrotal – deep to dartos
3. Need for imaging
 - a. Discussed in detail below

Depending on the physical exam findings, the patient will either need operative intervention, further imaging or no urologic intervention. Always bear in mind that imaging or urologic exam should *never* delay operative intervention by trauma surgery if operative intervention is indicated for non-urologic reasons.

54.4.1 Imaging

Possibly the single most controversial aspect in the management of penile/scrotal trauma is the appropriate use and timing of imaging. Based on the most current data, we will discuss if, when, and how to use imaging in the setting of acute penetrating penile/scrotal trauma.

54.4.1.1 Intravenous Pyelography (IVP)

The majority of data on IVP was collected in the 1980s–90s prior to the widespread use of Computed Tomography (CT). Series from that era noted the limited use of IVP to diagnose and localize injuries to the upper urinary tract [15]. In the setting of lower tract trauma it has not been utilized. IVP was not recommended as routine pre-op imaging in patients with penetrating abdominal trauma [16]. It no longer plays a role in American Urological Association (AUA) trauma guidelines. We discuss it here recognizing that in some situations, it may be the only imaging modality available. If CT is not available and the patient is stable, IVP can be used to help identify upper tract GU injury. Like most

modalities it should not delay operative intervention. In general, if there is a high index of suspicion and limited access to imaging, the authors suggest low threshold for operative exploration and intervention.

54.4.1.2 Triphasic Computed Tomography (CT Urogram)

In general stable patients with any suspected GU related injury should undergo CT Urogram to evaluate entire GU tract. As noted the most common site of GU injury are the kidneys. While far more rare, unrecognized ureteral injuries can be devastating. Generally, one should have low threshold for CTU in the assessment of GU trauma [17].

54.4.1.3 Ultrasonography (Ultrasound, U/S)

Ultrasound is one of the most useful imaging studies in the evaluation of scrotal trauma. Multiple series have demonstrated excellent sensitivity and specificity of scrotal U/S in the diagnosis of testicular injury [18, 19]. Given the availability and accuracy of this test, if the patient is stable, U/S can assist in the peri-operative management of scrotal injury to the degree that it would be reasonable to base operative intervention on U/S results.

Specifically, ultrasound allows for assessment of integrity of the tunica albuginea, hematoma, and blood flow to the testis.

In the case of penetrating scrotal trauma (deep to dartos), U/S can be forgone as the patient will need operative intervention. U/S is particularly useful in the setting of superficial scrotal injuries that may otherwise not require operative intervention.

Penile U/S has limited utility (discussed below).

54.4.1.4 Retrograde Urethrogram (RUG)

RUG remains the mainstay in the diagnosis of urethral injuries. Any patient with suspected urethral injury should undergo RUG if stable based on concomitant injuries. If there is a high suspicion for urethral injury and patient is not stable or

RUG not available, consider abdominal exploration for bladder injury and placement of suprapubic catheter [20–22]. Intraoperative cystoscopy can also be used to assess for urethral injury if RUG cannot be performed.

54.4.1.5 Cystogram

Cystogram plays a limited role in the management of penetrating penile/scrotal trauma. Typically these patients will present with CT scans if there is a concern for pelvic or intra-abdominal injury. If there is no exit wound visualized on physical exam or imaging suggesting intra-abdominal injury these patients are typically explored surgically and the diagnosis of bladder injury is made intra-operatively.

Cystogram can be useful in the setting of a patient who presents with blood at the meatus, no urgent need for intra-abdominal intervention, and a negative RUG. If the patient is stable, CT cystogram after catheter placement could be considered. Alternatively, cystoscopy could be considered in this setting, particularly if gross hematuria is present. If gross hematuria is persistent and not adequately managed with large bore catheter, guidelines would suggest exploration via extraperitoneal or intraperitoneal approaches depending on concomitant injuries.

In penetrating trauma, this could help demonstrate any injury to contiguous structures such as the rectum that may require intervention.

54.4.1.6 Magnetic Resonance Imaging (MRI)

MRI represents possibly the most controversial imaging modality in the setting of trauma. MRI, generally is less widely available, slower, and requires more expertise to read. While MRI has been shown to be safe in the setting of retained foreign bodies (i.e., bullet fragments) it has a very limited role in the acute setting of penetrating trauma to the penis/scrotum [23]. The most pertinent role for MRI has been in the evaluation of corporeal injuries in the setting of suspected penile fracture. This injury is sustained in a very different fashion and does not necessarily require immediate degloving and repair as with penetrating injury [24]. MRI should never

delay operative intervention for penetrating trauma.

54.4.1.7 Penile Doppler for Corporal Injury

Data on the use of penile Doppler for evaluation of corporal injuries comes from penile fracture evaluation. There is promising data that U/S with Doppler has diagnostic benefit in the pre-operative management of a patient with blunt penile trauma (e.g., penile fracture) [25]. It should never delay or substitute operative evaluation of penetrating penile trauma.

54.5 Penile Injuries

54.5.1 Corporal Injury/Repair

Suspected corporal injury due to penetrating trauma should always be managed with urgent operative intervention. Corporal injury should be managed to preserve erectile function as well as to identify possible occult urethral injuries. With urgent surgical intervention, corporal injury patients can have excellent outcomes with regard to ED and penile curvature. The literature suggests a peak long term ED rate of 54%, with most series suggesting ED rates of ~10–25% at about 4 years [26–30]. This differs from penile fracture, which has been shown to have good potential for maintenance of erectile function long term, even with treatment up to 7 days following initial injury [31]. Indeed, level I evidence suggests no change in ED rates with delay of repair up to 24 hours. This is important in the context of a patient presenting late or who has already undergone operative intervention for concomitant trauma injuries. In these patients, penile exploration should be considered [32].

Surgical management.

54.5.2 Injury of Urethra

The management of urethral injury from GSW have classically been categorized into two schools of thought, immediate primary repair vs.

conservative (non-operative) management through urinary diversion [33]. A third possibility has been raised recently, that is delayed primary repair of the urethra.

The goal of management of urethral injury focuses on minimizing immediate risk to the urethra and risk of urinary extravasation by utilizing appropriate urinary diversion, and minimizing long term risk of stricture or other complications. Classically, it was taught that following confirmation of a urethral injury (via RUG, etc.) the goal should be urinary diversion via suprapubic catheter.

Several large case series have shown that immediate primary repair of urethral gunshot injuries results in a lower rate of urethral stricture when compared to conservative management. The most recent AUA Urotrauma Guidelines are consistent with these observations, recommending “prompt surgical repair in patients with uncomplicated penetrating trauma of the anterior urethra.” [34]

We recommend prompt surgical exploration. In our experience, we have identified a role for delayed primary repair in a highly select subset of patients.

First, in a patient who is unstable and requires other operative intervention as quickly as possible or is too unstable to tolerate anesthesia, formal degloving, reconstruction and urethral repair may be safely delayed in this setting. Additionally, in a stable patient not otherwise necessitating operative intervention, urinary diversion with urethral or suprapubic catheter and delayed primary repair (24–72 hours) is feasible. This time period may allow for evolution of ‘blast effect’ and better delineation of tissue viability. This could be applicable if a urologist, or an opportunity to intervene, is not immediately available. As with any urethral injury, there should always be a high suspicion for concomitant corporal injury (please see above for detailed management of corporal injury).

It should be reiterated that delayed primary repair has *not* been documented in large retrospective or prospective series and is not reinforced by any current guidelines. We do not include it as a general recommendation, but

rather as ‘food for thought’. Surgeons should maintain a low threshold for operative exploration. Specifically in cases of isolated penetrating bulbar or posterior urethral injury, where urinary drainage and conservative management may be a more viable option compared to same in penile urethral injuries.

54.6 Scrotal Injury

Penetrating scrotal trauma is commonly seen in self-inflicted GSW due to the bullet trajectory of a weapon stored in a patients pocket or waistband. It is crucially important on physical exam to evaluate for the depth of the penetrating injury. Additionally, as with all ballistic wounds, the caliber and proximity of the weapon are important as far as understanding wound care and subsequently wound healing.

54.6.1 Superficial Injuries

If the patient has no concomitant injuries, a mechanism consistent with superficial injury and physical exam findings demonstrating only superficial wounds (no injury deep to the dartos layer), urgent operative intervention may not be required. At this stage it is critically important to rule out secondary ballistic trauma to the testicle with scrotal U/S with Doppler. If there is no finding of testicular injury, it is appropriate to manage the patient expectantly.

If the wound is large with significant skin loss, one can consider wound edge approximation, however formal closure would not be recommended. Grafting or more aggressive operative treatment is not advisable as it can be difficult to assess vascularity in the acute setting of ballistic trauma, and because the field may be prone to infection.

Typically, wound care with wet-to-dry dressings or simple antibiotic ointment is sufficient for secondary healing and often will have excellent cosmetic result. The routine use of oral antibiotic prophylaxis is not recommended.

54.6.2 Penetrating Injury of Testes

On assessment of the patient, if he has injury deep to dartos, urgent operative exploration is warranted. Operative intervention should be focused on preservation of testicles and ruling out any concomitant penile/urethral injury. As discussed above, scrotal ultrasound can be used in this setting, however it should not delay operative exploration in the setting of deep penetrating trauma.

Indications for surgical exploration would also include expanding scrotal hematoma, or an open wound where testicular injury is obvious, or acute or severe bleeding not amenable or responsive to compression or conservative management.

Intra-operatively, formal bilateral scrotal exploration should be performed with assessment of bilateral spermatic cords. If a pulse is not felt or testicular viability is questionable, Doppler may be used for testicular artery assessment.

If a testicular injury is recognized, attempts should be made to debride seminiferous tubules with closure of tunica albuginea with absorbable suture such as 4-0 polyglactin. If damage is too extensive or if spermatic cord or testicular hilar injury is identified, orchiectomy can be performed. If bilateral injuries are recognized requiring bilateral orchiectomy, consider urgent fertility consultation if possible.

54.7 Avulsion Injuries

The most severe GU trauma is traumatic avulsion of the penis/scrotum. These injuries are quite rare; even in large U.S. urban series they are often single digit cases of avulsion injuries [1, 3, 5, 13, 19, 35–37]. The etiology of these injuries also vary widely. Many series note up to 50% of these as self-inflicted. These injuries are more commonly reported in military blast/ballistic trauma settings than civilian settings. Civilian injuries may typically occur in industrial or agricultural (farm equipment) settings. Large series have divided these injuries into four types (detailed below) after initial stabilization and urinary diversion.

In the case of traumatic amputation or avulsion of penis, the critical step is assessment whether primary re-anastomosis of the penis is possible. This involves immediate control with debridement, repair, and appropriate urinary diversion. If the severed penis is available, it should be wrapped in saline soaked gauze and placed in biohazard or similar plastic bag, then this should be placed in ice/slush. Re-anastomosis should be attempted within 12 hours of ischemia to the severed penis [34, 37–39]. Re-anastomosis can be done microscopically with re-anastomosis of the dorsal artery, deep dorsal vein, and dorsal nerve. Data suggest lower rates of penile sensation loss, infection, and urethral stricture for microscopic repair. Erectile function rates are similar (~50%) [37, 39, 40]. Studies have also suggested the use of shunts to maximize graft viability [41]. Method of repair should be tailored to surgeon expertise.

If re-anastomosis is not possible, the focus should be on urinary diversion, control of other concomitant injuries, and closure to allow for possible reconstruction. The largest available series of reconstruction of avulsion injuries was done in Pakistan with delayed reconstruction with forearm free-flap [38]. In their series of 35 men treated from 1995 to 2003 they describe staged reconstruction with forearm free-flaps based on an injury type. In general, patient satisfaction with reconstruction is high. Delayed repair and graft reconstruction should reserved for cases where native severed phallus is not available or has undergone prolonged ischemic time.

- *Type I:* Proximal corpora intact and urethral meatus is on the surface of the palpable corporal stump. Both testis are present and the scrotal skin is usually uninjured.
- *Type II:* Near total corporal loss (crura intact). The meatus is at or slightly below the level of the pubic symphysis. There is partial or subtotal loss of the scrotal skin and loss of one or both testis. Testes may be in thigh pouch.
- *Type III:* patient is voiding through a perineal urethrostomy. No corpora present. The scrotum is usually absent in such cases and the

testes if present are located in the medial thigh skin.

- *Type IV:* Patients with type IV injuries have no identifiable urethra in the perineum and a supra-pubic catheter is in place. Scrotum and the testis is similar to type III [38].

A discussion of technique and results for phalloplasty is beyond the scope of this chapter.

54.8 High-Energy Injury (Military Bullets, IED/Land Mine/Blast Injury)

Since the early 2000s there was initially a prolonged period of global peace with relatively low numbers of individuals killed in war. Unfortunately, this has drastically increased in the last decade. In particular, there has been a dramatic increase in the rate of civilian war deaths and disabilities. According to international reports from the Syrian civil war, more than 250,000 civilians died, one million injured, and 4.8 million refugees displace to other countries since the year 2011. Some have pointed to advances in military technology to explain increased civilian deaths.

In contrast to low velocity missiles, high velocity missiles often produce a temporary cavity leading to a massive tissue destruction (see *Wound Ballistics*). Most high energy wounds are seen in military conflict, and thus our discussion of high energy wounds will largely target those treating personnel and civilians in military conflict.

Data collected from different civil war combats revealed a significant shift in genitourinary injury patterns toward the external genitalia. Of 169 urogenital injuries in Bosnia-Herzegovina, 26% sustained scrotal injuries and only 9.5% presented with penis injuries [42]. The prevalence of scrotal, testicular, and penile injuries among male U.S. military members involved in Iraq civil war were found to be 55.6%, 33.0%, and 31% respectively [43]. The routine use of the flak jacket by military personnel may account for the shift in injury patterns, as it offers great protection of both the chest and abdominal organs.

External genitalia trauma secondary to high energy injuries is frequently associated with injuries of other organ systems. Gomez et al. reported a 23 patients with genital gunshot wounds, of those 15 had a concomitant thigh injuries [44]. Similar findings have been documented by a group from Brazil [45].

The time from injury to evacuation from the combat frontline as well the experience of the evacuation team play a crucial role in the management of high energy penetrating injury [42]. The faster the time of evacuation, the higher the wound salvage rate. Moreover, the extent of tissue loss portends preservation of function in GU injury. This is particularly important in erectile dysfunction following penile injury. Unlike in low energy injuries, conservative treatments are not a feasible options in most of high energy injuries. Appropriate hemostasis, debridement and repair of the damaged structure are the main goal of surgical treatment. Life-threatening hemorrhage from genital injuries are seldom reported. Hemostasis of the corpora cavernosa or spongiosum is usually achieved by careful repair of the tunica albuginea. Deep sutures to the corpora provide minimal hemostatic benefit and will affect the erectile tissue leading to possible ED or curvature. Vigorous irrigation and wash along the bullet track is a critical step to maintain a clean wound, particularly in close range shotgun wounds, which usually contain large numbers of pellet, powder grains and other foreign materials. Debridement of necrotic nonviable tissue is similarly crucial to reduce infection. Due to massive tissue destruction generated by high energy injuries, most authors suggested a planned staged surgical repair of damaged structures. The Authors recommend initial damage control and debridement of non-viable tissue, and subsequent reconstruction planned in an elective manner, often after an appropriate delay such as 3 months (Fig. 54.2).

Hudak et al. reported a 3-year experience in management of GU trauma from the Iraq war [42]. The most performed surgical procedure was the repair of penile and/or scrotal injuries. Staged genital reconstruction was required in extensive soft tissue loss from blast and high energy bullet

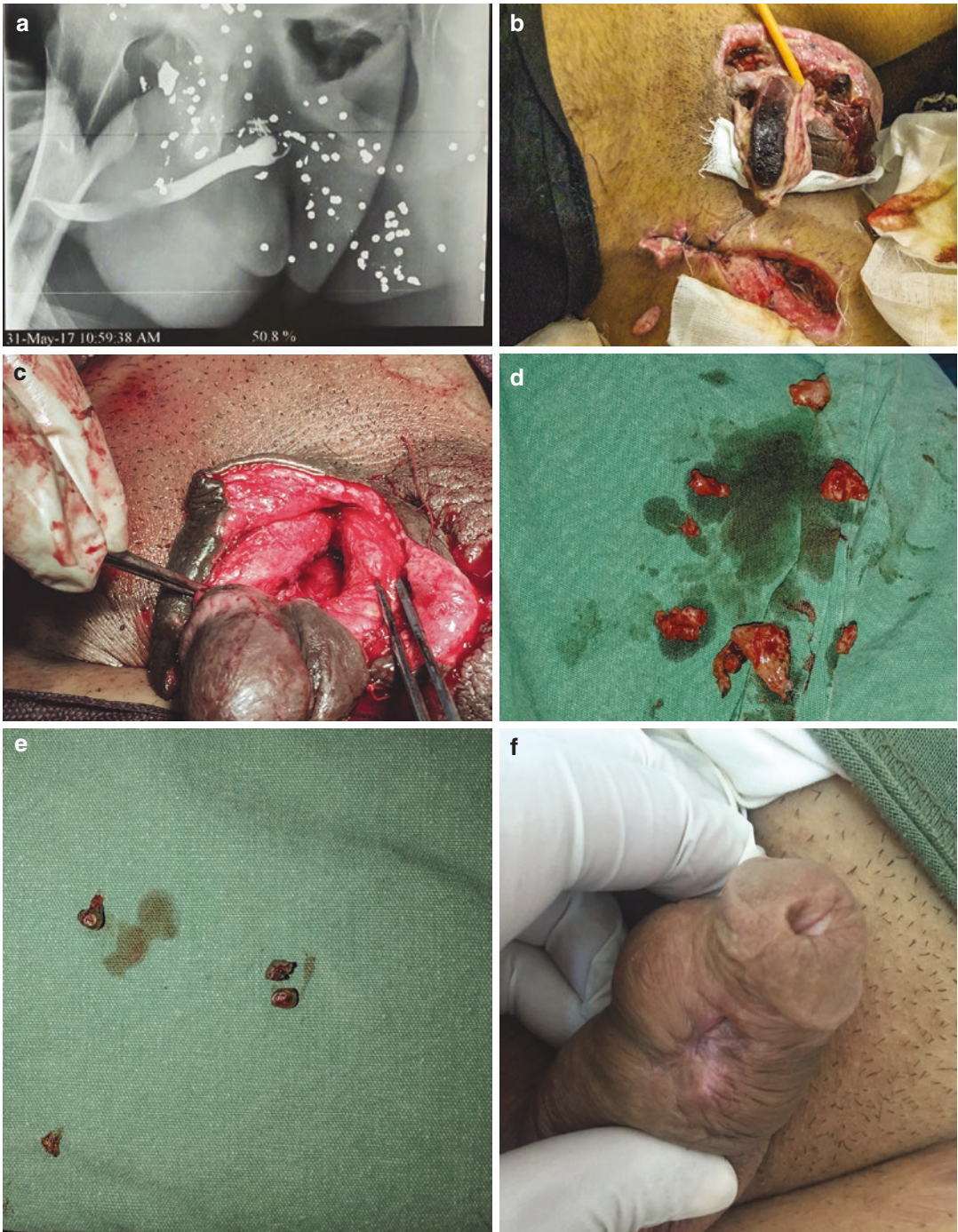


Fig. 54.2 Gunshot Wound to the External Genitalia. High Velocity/Military Grade Injury. **a.** X-ray demonstrating wide field shrapnel to pelvis and genitalia. **b.** Initial physical exam - significant deformity and tissue destruc-

tion. **c.** Subsequent operative debridement and repair. Urethral mobilized from corpora. **d.** Debrided nonviable tissue fragments. **e.** Shrapnel removed from the wound. **f.** Follow-up after 3 months

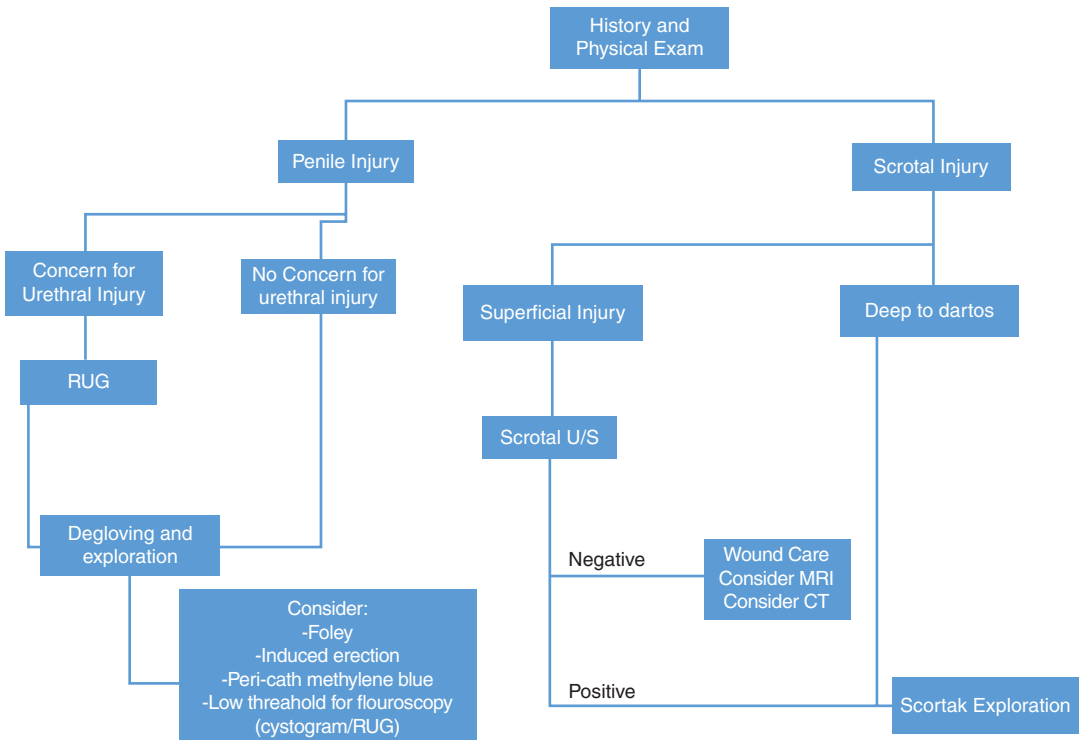
injuries. Associated urethral and/or corporal injuries were evident in about half of the cases of penile injury with 46.0% of patients undergoing penoplasty and/or corporoplasty, while the rest required only debridement and the repair of superficial injuries.

In the initial assessment it is important to remember that the gross appearance of the scrotum is not a reliable predictor of the severity of underlying testicular injury. In many instance, tiny lacerations of the scrotum can be associated with occult testicular rupture. This is quite different from low energy injuries. Therefore, conservative treatment of high- velocity testicular injury is often not possible. Scrotal exploration has become a routine practice to stage penetrating scrotal trauma even if the initial injury appears superficial. If available, scrotal U/S remains a useful and accurate diagnostic test for assessment of testicular injury/rupture, but should not delay

operative intervention if the surgeon has a high index of suspicion for injury. Of the 88 testicular injuries, Hudak reported that orchiectomy was required in 48.9% of cases [46]. Similar results were reported by Brandes et al. [47] and Phonsombat et al. [5], in which orchiectomy performed in 52% and 51% of all surgical exploration cases respectively.

54.9 Conclusion

Penetrating GSW injuries of male external genitalia are rare but clearly serious. Rapid assessment through history and physical exam, and prudent use of imaging, can guide treatment. Conservative management can be employed in certain situations, but a high index of suspicion for corporal, testicular, or urethral injury warrants prompt surgical exploration and repair.



Key Summary Points

- Penetrating GSW of male genitalia are rare but serious.
- Bullet wounds may be considered as low and high energy injuries, which generally coincide with civil and military settings, respectively.
- Tissue damage occurs by direct damage and in high energy wounds, from cavitation effect as well.
- Focused history and physical exam are key to assessment.
- Imaging may not be available in the acute setting, and whether it is necessary is controversial. Retrograde urethrogram is useful when urethral injury is suspected, and ultrasound may have utility in evaluating the testes in scrotal injury.
- In penile injury, corporal injuries should be repaired primarily. Urethral injury is generally repaired primarily, but may be managed conservatively.
- Superficial scrotal injuries can be managed conservatively, while those deep to the dartos warrant scrotal exploration. Debridement and repair of testicular injury is preferable if possible, but if extensive, orchiectomy may be required.
- High energy injuries are generally managed similarly, but bearing in mind the higher incidence of concomitant and more serious injuries. Because of this, there is a lower threshold for intervention, but also more reliance on staged treatment.
- In avulsion of the genitalia, salvage of the penis with re-anastomosis should be attempted. If not possible, the urine should be diverted, and other injuries managed, with a plan for subsequent reconstruction later.

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Organ-Preserving Surgical Treatment of Penile Cancer and Glans Lichen Sclerosis

55

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55.1 Introduction

Penile cancer is a rare urological cancer with an incidence of less than 1 per 100,000 men [1]. The most common pathologic variant is squamous cell carcinoma, accounting for approximately 95% cases. The main risk factors include phimosis, chronic penile inflammation, balanitis xerotica obliterans, smoking, human papilloma virus, multiple sexual partners, early age at first intercourse [2]. Penile cancer is almost never seen in men circumcised at birth, however prophylactic circumcision is not standard of care and is a very controversial topic [3–5].

The reasons behind why a neonatal circumcision is protective are multifactorial. The lowest incidence of penile cancer is reported in the Jewish population in Israel at 0.3/100,000/year, where cultural circumcision at birth is almost universal [1]. Phimosis can lead to chronic

inflammation of the glans penis due to an accumulation of smegma- although smegma itself is not carcinogenic. Furthermore, circumcision removes approximately 50% of the tissue that penile cancer can develop on.

The natural history of penile cancer is well established. The majority (over 80%) of penile cancers are located on the glans, the coronal sulcus or the prepuce [6]. This lends penile cancer well towards an organ sparing approach. Traditionally a diagnosis of penile cancer resulted in a radical excision with greater than 2 cm surgical margin- this resulted in satisfactory oncological outcomes but significant morbidity to the patient.

In the modern era, surgery has moved toward a 'less is more' approach. Organ preserving surgery is now standard of care for many oncological conditions- partial nephrectomy for stage 1 kidney cancers, endoscopic management for upper tract urothelial cancers, focal therapy for some local prostate cancers, partial orchiectomy for small testis cancers and bladder conserving treatment even for some muscle invasive bladder cancers are well recognized treatment strategies within uro-oncology.

Patients want less invasive procedures, quicker return to pre-operative function, shorter stays in hospital and quicker return to work. As a result, there has been a relative explosion in the use of minimally invasive surgery worldwide. Robotic prostatectomy is now performed more commonly

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than the traditional open prostatectomy. Although there has yet to be any level one evidence proving advantageous oncological or functional outcomes- there are recognized benefits such as less blood loss, shorter length of stay and quicker return to function [7, 8].

Organ preserving surgery is well described in penile cancer. It has been proven to be oncologically safe but most strikingly there are improved functional outcomes for patients in what was previously a life altering diagnosis [9–11]. Given that penile cancer is such a rare disease, centralization of the service to supra-regional centers has been demonstrated to be advantageous [12].

The adoption of organ sparing surgery has varied. Data from the SEER database from USA has shown that the use of conservative penile surgery has not changed with time [13], however the centralization for penile cancer care in the UK has resulted in an increase in the use of organ-sparing surgery [14]. In contrast, data from a population study Australia showed 70% of penile procedures performed are still radical [15].

The effects of radical penile surgery are profound Figs. 55.1 and 55.2- patients often have to change their voiding pattern, have significant deterioration in sexual function and have negative psychological effects in increase anxiety, mood disorders and suicide rates [16–18].



Fig. 55.1 Specimen from total penectomy



Fig. 55.2 Vertical rectus abdominus musculocutaneous (VRAM) flap used to cover defect

55.2 Rationale for Penile Preserving Surgery

The main concern regarding any organ sparing approach is oncological safety. Is it possible to obtain a clear surgical margin, are there higher rates of recurrence and is there any effect on survival?

There unfortunately have been not randomized control trials in this field- the cumulative evidence stems from retrospective studies conducted in a very heterogeneous manner.

1. Up until relatively recently, a 2 cm surgical margin was deemed necessary for an oncologically sound operation. This changed with the publication of updated guidelines by the European Association of Urology (EAU) in 2005, setting a new clearance margin of only 5 mm, which remains the standard in the most recent guidelines from 2014 [1].

In 2000, Agrawal et al., reviewed 64 penectomy specimens with a view to determining the microscopic spread of the tumor beyond macroscopic margins. They examined the specimens serially in 5 mm cuts. They concluded that 81% did not extend beyond visible tumor margins and of those that did, only 25% extended more than 5 mm

from the margin [19]. Minhas et al., performed a similar study, this time assessing penile-preserving techniques. They concluded that despite 92% of patients having a less than 20-mm margin (48% of which was <10 mm), only 3 (6%) patients had positive margins [20]. Both studies adding support to the hypothesis that excision margins of less than 10 mm was safe in line with the updated guidelines.

2. The evidence for the importance of margin status after penile surgery is variable. The EAU guidelines report recurrence rates varying from 4% in partial penectomy and up to 48% following laser therapy. Djajadiningrat et al. found that while a positive margin after penile surgery resulted in more local recurrences, it did not have an effect on overall survival [21].
3. The concern regarding a higher positive margin rate and a higher local recurrence rate is that this may negatively impact on survival. Despite this, in a study of 859 patients, no difference in cancer-specific survival was demonstrated between the two groups with a 65 month follow up [21]. During the study period, the rates of penile preserving surgery increased without jeopardizing survival. The recurrence rate in the study was 27% which was higher than in the amputation group however the overall (67%) and 5 year cancer specific survival (81%) was equivalent.

The key to the safety of penile preserving surgery is close clinical observation (active surveillance strategy) and early re-resection of any suspicious lesion. This highlights the importance of tertiary referral centers for penile cancer [12]. Breen et al. highlight the importance of adherence to guidelines in this rare cancer, which again supports the concept of supra-regional centres for the management of penile cancer [22]. Patel et al., reported a decrease in survival by 36% in patients managed in low volume centers [15].

55.3 Types of Organ-Sparing Surgery

There are a variety of organ sparing techniques available for the surgical management of penile cancer. The optimal modality is not clearly defined. The decision is based upon the size of the lesion, the location of the lesion, the functional status of the patient, the surgeon's expertise and the patient's preference.

55.3.1 Laser Therapy

Laser ablation of penile lesions can be performed using one of two types of laser fibre; the Nd:YAG which is a deeply penetrating coagulative laser measuring 3–5 mm in diameter, or the CO₂ laser fibre which is a vaporizing fibre with a shallow depth of penetration measuring 2–3 mm. Lasers are best used for in situ lesions, however their use has been described in the management of a spectrum of cancers up to those as advanced as T2 lesions.

Both lasers have been applied with reported good functional and cosmetic outcomes. Nd:YAG and CO₂ are the most common laser mediums reported in the literature with local recurrence rates ranging between 11% and 48% in patients with CIS or pT1 tumors [23, 24]. A large series of 700 patients, of whom 289 underwent laser therapy with Nd:YAG and/or CO₂, showed a similar local recurrence rate of 27.7% [25].

It can also be performed as an outpatient procedure. However unless used as a scalpel technique there is absence of a histology specimen.

55.3.2 Mohs Micrographic Surgery

Mohs micrographic surgery (MMS) is used for the resection of many dermatological lesions. Mohs surgery is based on sequential tissue excision under repeat microscopic control. The excised layers of tissue are spatially oriented and reviewed by the same surgeon. The desired

advantage is to accurately identify tumor margin and to maximally preserve uninvolved tissue. The first case series of MMS for SCCA of the penis was reported in 1985 by Mohs et al. in 29 patients [26]. MMS entails immediate horizontal frozen sectioning of the entire margin of excised tissue with mapping and microscopic identification of remaining tumor. This is followed by repeat excisions, mapping and examination until a tumor-free plane is noted throughout. Final pathology slides can be reviewed by a pathologist to obtain any needed pathological information, such as grade and lymphovascular invasion that may aid in future treatment planning.

Shindel et al describe a series of 33 patients undergoing 41 resections. Five procedures were terminated with positive margins, including three due to urethral involvement and two due to defect size. Eight patients (32%) had recurrence, which was managed by repeat Mohs micrographic surgery in seven and by penectomy in one. There were two cases of tumor progression, including one from T1 to T3 disease (meatal involvement) and one from T1 to inguinal lymph node involvement [27].

Concerns regarding recurrence have also been highlighted, with Mohs himself acknowledging that distal tumors had much better cure rates, compared with just 57% in cancers with penile shaft involvement. Size, too, has implications, with Mohs citing only a 50% cure rate for lesions larger 3 cm [28]. It has not been widely adopted for the management of localised penile cancer.

55.3.3 Glans Resurfacing

Glans resurfacing involves removal of the epithelial and subepithelial tissue of the glans with extragenital skin graft applied [29]. It was initially described by Bracka to surgically manage severe balanitis xerotica obliterans of the glans [30]. Since being adapted for Tis, it has become the gold standard surgical treatment for glanular lesions up to T1a; however, partial glans resurfacing may be offered in the absence of multifocal tumor, if glanular involvement is below 50% and only for tumors up to Ta, Fig. 55.3. This can



Fig. 55.3 Malignant lesion of the glans

be partial or total excision of the glans, which is combined with split-thickness skin grafting thereafter to maintain function.

The skin can be taken retrogradely in quadrants or anterogradely en block with foreskin, corona and glans, and be mounted for histopathology on a syringe plunger. O'Kelly et al. recently described the procedure as performed in our unit- Total glans resurfacing is performed with the patient under general anesthesia using a tourniquet. The glans epithelium is marked in quadrants from the meatus to the coronal sulcus. Perimeatal and circumcoronal incisions are made. The glans epithelium and subepithelial tissue are completely removed off the underlying spongiosum starting from the meatus to the coronal sulcus for each quadrant using a round-handled scalpel with a No. 15 blade. Deep spongiosal biopsies are taken from each quadrant for intraoperative frozen section with particular reference to the sub tumor tissue to ensure no invasion. A split-thickness skin graft (0.008–0.016 inches) is harvested from the thigh with an air dermatome and used to cover the glans. The graft is sutured and quilted using multiple 5-zero interrupted Vicryl Rapide™ sutures [9].

Glans resurfacing, like wide local excision, is most appropriate in those with low-grade disease in the absence of lymphovascular invasion. An emphasis should be placed on regular self-



Fig. 55.4 Outcome 2 years post total glans resurfacing

examination and patients should be carefully selected in an attempt to ensure compliance with follow-up, Fig. 55.4. Despite clear benefits to glans resurfacing, positive margins persist as a challenge, with 48% of a mixed partial and total glans resurfacing cohort affected and 28% requiring further surgery most often in the form of total or partial glansectomy [10].

During this prospective study of functional outcomes – 94% had complete graft take while all patients who were sexually active pre-op were functional with 6 months. Surprisingly 81% of patients believed that their sex life had improved since resurfacing, they had normal glans sensation and all scored 4 or 5 of 5 on a visual analog scale with no evidence of sexual dysfunction [9]. The local recurrence rate is ~4–6% [1, 9].

55.3.4 Wide Local Excision/Partial Glansectomy

Patients with low grade lesions up to T1a can be managed with a wide excision (likely involving a modified circumcision). In most cases the lesion involves minimal amounts of the glans or the coronal sulcus and a primary closure leaves only minor cosmetic defect. This procedure can be

and is often combined with a glans-resurfacing. For invasive glans lesions treated by WLE there is a risk of metachronous lesions, hence our preference to resurface the glans to manage that risk.

55.3.5 Glansectomy

Glansectomy is a safe approach for larger lesions confined to the glans. The glans is completely separated from the corporal heads. The urethra is transected and a urethrostomy is formed distally. The urethra needs to be mobilized to achieve length for when the urethra is spatulated to prevent stenosis.

The procedure is performed under a general anesthetic with a penile tourniquet in use. A circumferential incision 1 cm below the corona is made – staying external to Bucks fascia. Depending on the location and extension of the penile lesion, a plane of dissection should then be created, before the glans penis is dissected free, Fig. 55.5. The corporal bodies can be oversewn with 2/0 Vicryl. A split skin graft can be harvested to form a neoglans. Shaft skin can be advanced to the level of the ‘neo-corona’ [10]. If there is sufficient length of glans it is mobilised between corporal tips so as to achieve a central vertical slit akin to the aim of hypospadias repair. If the urethra is limited in length it should be spatulated ventrally.

One of the larger studies from the United Kingdom examined 72 consecutive patients who



Fig. 55.5 Intraoperative glansectomy



Fig. 55.6 Glansectomy with resurfacing using skin graft

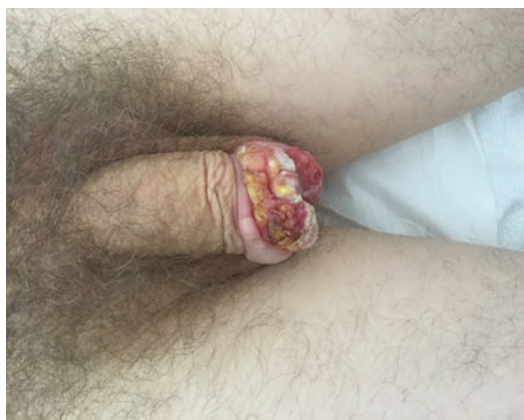


Fig. 55.7 Large malignant lesion of the glans

underwent glansectomy for penile carcinoma [31]. At a mean follow up of 27 months there were 3 recurrences at 4, 19 and 28 months, respectively. In this cohort 51% of the men had T2 disease.

For more advanced disease- glansectomy has the advantage of excellent cosmetic results with good phallic length preservation with comparable recurrence rate to partial penectomy, Fig. 55.6.

55.3.6 Partial Penectomy

Partial penectomy is achievable for any lesion extending to the shaft where there is still an ability to leave a penile stump, Figs. 55.7 and 55.8.



Fig. 55.8 Partial penectomy

A skin graft can be used to form a neoglans or alternatively- shaft skin can be brought up to surround the urethra.

A concern with partial penectomy is retraction of the stump which can cause issues for voiding as well as there being insufficient length for erectile function. Despite this- many men still prefer this option as opposed to total amputation.

Recurrence rates range up to 20%, with recurrence being more likely in more advanced tumours i.e., T3 lesions [32].

The choice of which procedure to offer each patient is a shared decision between the patient and the surgeon.

55.4 Lymph Node Management

Regardless of the management of the primary lesion, lymph node status needs to be assessed in all patients with penile lesions. Patients with Tis, Ta G1 and T1 G1 can undergo surveillance of lymph nodes with regular clinical examination. Any patient with T1 G2 or above needs invasive nodal staging with either dynamic sentinel lymph node biopsy (DSLNB) or bilateral modified inguinal lymph node dissection. DSLNB can be

offered at the same time as penile sparing surgery however bilateral inguinal node dissections may interfere with the healing of the penis if done at the same time.

Patients with palpable nodes undergo modified inguinal lymph node dissection.

55.5 Histology/Frozen Section

Patients presenting with penile lesions often undergo a biopsy to confirm diagnosis prior to definitive surgery.

Once confirmed as a penile cancer, the role of the histopathologist is crucial to an organ preserving service. Intra-operatively- a histopathologist has an important role in determining margin status. It is imperative that there is correct orientation of the specimen and discussion between the surgeon and the histopathologist to give accurate clinical information. A challenge with penile cancer is that a lot of lesions have a well differentiated squamous cell growth that can mimic non-neoplastic lesions [33] and vice versa some hyperplastic lesions can have a pseudoepitheliomatous appearance.

Examination of intraoperative frozen sections adds time and cost to the procedure however it can give the surgeon confidence to pursue an aggressive organ sparing approach and preserve as much healthy tissue as possible.

Frozen section has been associated with a negative predictive value of 100% and a positive predictive value of 93% for urethral margin status at radical cystectomy. Frozen section is readily used in radical prostatectomy to facilitate aggressive nerve sparing approaches with sensitivities above 90%.

Patients however need to be aware of the false negative rate associated with frozen section and the implications of discordance between the frozen section and final pathology.

55.6 Lichen Sclerosis

The European Association of Urology guidelines identify lichen sclerosus (LS) or balanitis xerotica obliterans (BXO) as a strong risk factor for

penile squamous cell carcinoma. This is controversial. The presence of histologically-confirmed synchronous LS/BXO in patients diagnosed with penile cancer is relatively high although it is not associated with an increased risk of adverse histopathological features.

Lichen sclerosus/balanitis xerotica obliterans (LS/BXO) is a chronic inflammatory process of unknown aetiology affecting the glans penis, prepuce and urethra. LS/BXO affects primarily the glans penis and prepuce of uncircumcised men and presents as pale, atrophic plaques, which may coalesce and sclerose, causing phimosis and meatal stenosis.

Primarily, patients with BXO can be treated with topical agents and circumcision. Topical steroids have been shown to reduce the need for circumcision by up to 35% [34]. Patients with persistent scarring BXO should be referred for specialist opinion. In such patients who have extensive recurrent BXO- removal of the glans epithelium (glans resurfacing) has been proven to be effective both cosmetically and functionally [35, 36].

55.7 Conclusion

Organ preserving surgery is a safe and acceptable treatment option for penile cancer. Organ preserving surgery should be paramount in a surgeon's discussion with any patient presenting with a penile cancer and should be offered in all cases where feasible. The optimal modality of penile preserving surgery is uncertain. A shared decision making process is required with the patient outlining the risks and benefits of each and tailoring these to the patients presentation and expectations. A strict surveillance protocol is required for any patient who undergoes organ preserving surgery, Table 55.1. Early review, biopsy and resection are essential for any change or suspicious lesion to outrule disease recurrence. The detection and management of lymph nodes is also an important consideration even with organ sparing surgery. Patients undergoing penile preserving surgery should be managed in a supra-regional multidisciplinary network with a focus on the oncological, functional and psychological care of the patient.

Table 55.1 Surveillance protocol for patients with penile preserving surgery

	3 months	6 months	9 months	12 months
Year 1	Clinical exam	Clinical exam	Clinical exam	Clinical exam
Year 2	Clinical exam	Clinical exam	Clinical exam	Clinical exam
Year 3		Clinical exam		Clinical exam
Year 4		Clinical exam		Clinical exam
Year 5				Clinical exam

Key Summary Points

- Radical penectomy for penile cancer has significant effects on patient's functional and psychological well-being and is not always necessary from an oncological perspective.
- Penile preserving surgery is a safe and feasible option for penile cancer with good oncological and functional outcomes.
- The optimal modality for penile preserving surgery is unclear.
- Close surveillance protocols are important with an emphasis on early review, biopsy and re-resection of any suspicious lesion.
- Penile preserving surgery should be offered in a supra-regional network setting.

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Surgical Reconstruction of Buried Penis

56

Paul J. Rusilko, Thomas W. Fuller, and Frank Burks

56.1 Introduction

The buried or concealed penis is a well described congenital phenomenon in children with multiple large case series and classification systems published to help guide management. The etiology is occasionally iatrogenic such as in overly exuberant circumcision. More commonly pediatric buried penis is due to lack of fixation of the skin at the base of the penis accompanied by inelastic or dysgenetic dartos fascia and abundant suprapubic fat of infancy [1–3]. In contrast, adult buried penis is an acquired condition. Broadly there are two causes for adult acquired buried penis (AABP). The penis can be trapped because of post procedural cicatrix formation or genital skin loss. The alternative is an expansion of tissue over and eventually encompassing the penis as in genital lymphedema or morbid obesity. In either case, the result is entrapment of the penis with

associated morbidity that includes sexual dysfunction, lower urinary tract symptoms (LUTS), development of urethral stricture disease, local skin excoriation, poor body image, and depression. Surgical repair of the adult buried penis is less well described than in the pediatric literature. However, a growing body of literature regarding technical approach and patient centered outcomes is emerging over the last several years.

The nomenclature for adult buried penis has not been entirely standardized but in recent years it has been largely codified as concealed penis or adult acquired buried penis. Alternative less frequently used nomenclature in contemporary reports include inconspicuous penis, hidden penis, or trapped penis. Authors have argued that adult acquired buried penis and concealed penis are still not specific enough and an etiology of the condition should be included as surgical approach to repair can be quite disparate depending on the inciting cause. For instance, a post circumcision or lichen sclerosus induced cicatrix with preserved penile skin may be approached much differently than a buried penis due to morbid obesity or genital lymphedema with penile skin loss and a large suprapubic fat pad (escutcheon) [3–5].

For complex cases with a large escutcheon and loss of penile skin interventions have evolved from limited repairs in which attempts were made to tack the overlying adiposity to the pubic bone to wider adoption of escutcheonectomy (suprapubic fat pad lipectomy) and penile

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split-thickness skin grafting (STSG). Despite advances in surgical technique complications are still relatively commonplace. This is particularly true for wound complications; frequently in the setting of morbid obesity associated diabetes mellitus (DM). Management strategies to limit wound complications include use of bolster dressings, fibrin glue for STSG apposition, and negative pressure dressings [6–11].

Though surgical repair is challenging and wound complications are common patients routinely describe improvements in urinary, sexual, and overall quality of life. A majority of patient would undergo surgical intervention again when asked in postoperative follow-up [12, 13].

56.2 Epidemiology

No specific data for the incidence and prevalence of AABP exists. Most authors refer to a likely overall increase in relation to a rising rate of obesity. The World Health Organization (WHO) describes a worldwide obesity epidemic. Notably, obesity tripled since 1975 and in 2016 there were 1.9 billion (39%) and 650 million (13%) overweight and obese adults in the world respectively. The trend is likely to continue as more than 340 million children and adolescents were overweight or obese in the same year [14].

56.3 Etiology and Pathophysiology

Regardless of the etiology the morbidity of AABP is similar. Penile burying results in LUTS, sexual dysfunction, and poor genital hygiene. Chronic moisture from urinary pooling leads to local inflammation and infection with accompanying skin breakdown and ultimately the development of lichen sclerosus (LS). It has also been suggested that LS has an association with systemic chronic diseases such as hypertension and DM which are commonplace in AABP. As a result of LS, or the underlying inflammatory or systemic condition that caused it, urethral stricture disease is increasingly recognized as a

comorbid condition. Patients frequently develop depression as a result of their urinary, sexual and hygienic limitations. Additional comorbidities with morbid obesity and AABP include hypertension, obstructive sleep apnea (OSA), and diabetes mellitus (DM). Diabetes is an especially important factor to identify and control as it can exacerbate wound healing that is already challenging in AABP [13, 15–18].

56.3.1 Morbid Obesity and Lymphedema Associated AABP

In the case of burying due to a suprapubic fat pad or genital lymphedema, the corporal bodies are fixed to the pubic bone by the suspensory ligament of the penis and are unable to migrate peripherally with encasing adiposity or lymphedematous tissue [19]. It has been suggested that individuals can be congenitally prone to this process as a result of dysgenetic dartos tissue that is poorly adherent to the corporal bodies allowing distal bunching of the penile skin [20]. As the penis is buried chronic local moisture from skin apposition and urinary dribbling allows bacterial and fungal overgrowth and chronic infection that leads to inflammation and skin fibrosis. Thus morbid obesity can lead to fibrosis of the penile skin and cicatrix formation combining the two etiologies of buried penis.

Acquired chronic genital lymphedema in adulthood can be a result of trauma, inflammatory autoimmune condition, radiation, infection, neoplasm, or post-surgical scarring. An exhaustive search for the cause should be undertaken and controlled prior to consideration of surgical intervention. Systemic steroids can be effective for inflammatory conditions and antimicrobial agents treat filarial or sexually transmitted bacterial infections. Infectious causes can cause persistent lymphedema after eradication of the microbiological etiology from post inflammatory fibrosis.

Surgical principles with genital lymphedema include resection of all involved skin including the dermis and dartos tissue which contains the

lymphatics. Special attention is required to resect all skin up to the corona to prevent a post-operative ring of edematous tissue distally on the penis. The posterior scrotum has separate lymphatic drainage and can be used for tissue coverage. Lymphangioplasty (establishing new lymphatic drainage) has been trialed and largely unsuccessful in this setting [21–23].

56.3.2 Cicatrix

Cicatricial burying is due to a peripheral ring of scar tissue frequently formed as a result of adult circumcision or lichen sclerosus. In the post circumcision setting, the coronal incision and bunched penile skin contracts to form a circumferential dense scar that traps and conceals the penis. There is often an element of obesity that leads to distal bunching of the penile skin. Definitive surgical repair is reliant on resection of diseased tissue and prevention of recurrence [4] (Fig. 56.1).

56.3.3 Lichen Sclerosus Associated Buried Penis and Urethral Stricture Disease

Lichen sclerosus, formerly referred to as balanitis xerotica obliterans (BXO), is a lymphocyte

mediated inflammatory condition of the genital skin and urethra that causes urethral stricture disease [24]. LS is frequently present on final pathologic evaluation of penile skin in AABP specimens (41–57%) [13]. LS can be a contributing factor to developing AABP by creation of a cicatricial ring of fibrotic skin over the glans. It is likely a contributing factor to a higher rate of urethral stricture disease in patients with AABP. Reports from the largest available series, where stricture presence was evaluated as an endpoint, quote a stricture rate of 33–47%. The most common location is the meatus and fossa navicularis but bulbar and panurethral stricture disease is also noted. There is some disagreement whether isolated bulbar strictures can be caused by LS or if they are an associated, but not causally linked, pathology.

Preoperative evaluation for stricture disease is advisable given the high prevalence and the affect AABP repair can have on urethroplasty surgical options. Contemporary AABP repair frequently involves resection of the majority of penile skin and dartos tissue with STSG coverage. Bulbar and panurethral stricture disease is often amenable to a perineal approach with penile invagination and dorsal onlay buccal mucosa graft. The presence of STSG can precludes the ability to invaginate the penis for a perineal repair and lack of dartos tissue limits urethroplasty coverage in a penile approach. Preoperative retrograde urethrogram when the

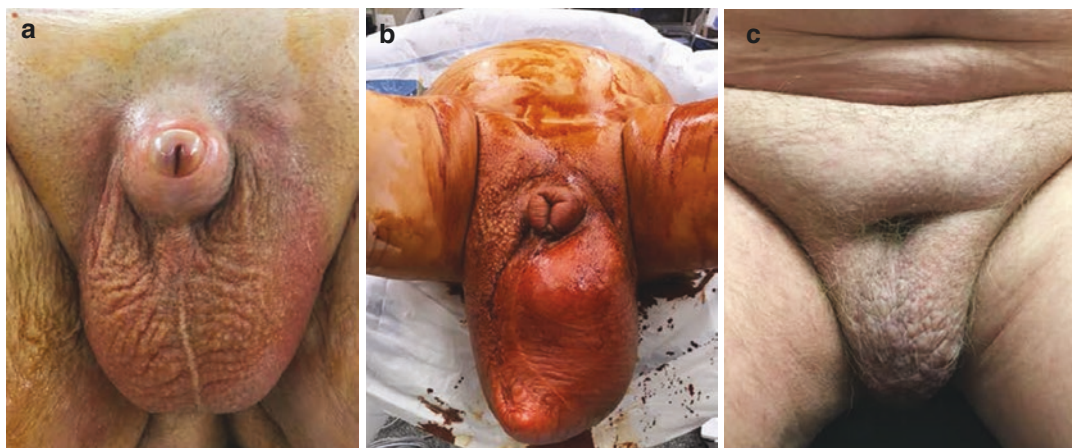


Fig. 56.1 Adult-acquired buried penis etiologies. (a) Post circumcision cicatrix formation. (b) Primary genital Lymphedema. (c) Obesity with a large suprapubic fat pad (escutcheon)

Table 56.1 Contemporary series with Mean BMI and rate of relevant comorbidities

Series	Patients (n)	Mean BMI (kg/m ²)	Comorbidities (%), (NR = not reported)			
			DM	OSA	HTN	Depression
Pariser et al. [16]	64	45	32	NR	NR	NR
Theisen et al. [17]	16	45	56	NR	56	25
Hampson et al. [13]	42	46	48	74	67	NR

meatus is accessible or cystoscopy when there is difficult passing the catheter at the time of surgery has been advocated [16, 18, 25].

56.4 Preoperative Considerations

56.4.1 Comorbidities and Preoperative Evaluation

Evaluation of the AABP should begin with a focused history and physical exam. Of particular interest is a past history of genitourinary infection, radiation, trauma and surgery. Recurrent episodes of balanitis, long duration of penile burying, and history of circumcision with postoperative cicatrix formation imply the penile skin may be unusable in repair necessitating graft coverage. Erectile function and desire for sexual activity should be assessed and may affect surgical approach. Urinary function should be queried as severe LUTS are typical and can imply the presence of urethral stricture.

Notable physical exam findings include the viability of penile skin, condition of the meatus when visible, presence and severity of incontinence or urinary dribbling associated dermatitis, presence of lichen sclerosus, and degree of penile and scrotal lymphedema. If escutcheonectomy is being considered physical exam and available imaging should be reviewed for the presence of inguinal hernias to prevent inadvertent bowel injury when the spermatic cord and inguinal rings are isolated. The escutcheon skin can have lymphedema which is notable if it is being considered as a potential donor site for STSG. Penile tumors are infrequent but should be considered as cases have been reported of invasive squamous cell cancer despite neonatal circumcision.

Patients with AABP due to morbid obesity often have multiple associated comorbidities. Large modern series report high rates of DM (32–56%), hypertension (56–67%), and OSA



Fig. 56.2 Redundant skin folds after substantial weight loss leads to persistence of adult-acquired buried penis

(74%) [13, 16, 17]. Preoperative optimization is imperative to prevent postoperative complications (Table 56.1). Diabetes is well known to be deleterious to wound healing and hemoglobin a1c, a measure of glucose levels over the preceding 90 days, should ideally be $\leq 7\%$ indicating close glucose control [26, 27].

Similarly, active smoking is associated with a variety of wound complications including prolonged healing time, tissue flap necrosis, and wound infections. In contrast, smoking cessation has been linked to a decrease rate of many of these complications. Patient should be counseled regarding this information and every effort made to promote smoking cessation preoperatively [28].

Weight loss alone is not frequently sufficient after morbid obesity induced AABP as overhanging skin flaps and likely long term damage to penile skin persists. Referral to bariatric programs including consideration of bariatric surgery should be initiated to address the patient's overall health and functionality (Fig. 56.2).

56.4.2 Staging

Contemporary high volume AABP surgeons have developed classification systems based on degree of penile burying, viability of penile skin, and subsequent complexity of repair to allow for improved surgical planning and patient counseling. Tausch et al. distinguishes patients with viable penile skin (Grade 1) from those with non-viable penile skin (Grade 2) and those with genital lymphedema (Grade 3). In their series of 56 patients, Grade 1 patients were managed with phalloplasty with or without suprapubic fat panniculectomy (escutcheonectomy). Grade 2 patients required addition of STSG as did most of Grade 3 patients. With increasing complexity and the need for STSG and panniculectomy there was diminished success rates as defined by need for subsequent procedures [5].

Pariser et al. alternatively suggested a five category surgical repair classification system from a series of 64 patients as follows:

- Category 1 – Penile unburying with local skin flap.
- Category 2 – Use of skin graft.
- Category 3 – Scrotal surgery (scrolectomy or scrotoplasty).
- Category 4 – Escutcheonectomy.
- Category 5 – Abdominal panniculectomy.

Patients were classified in the highest category of complexity they required for repair. Though low-grade complications (Clavien 1–2) were similar between high and low complexity repairs (categories 1 and 2 and categories ≥ 3 respectively), there were more

high-grade complications (Clavien ≥ 3) in complex repairs [16, 29].

56.4.3 Patient Counseling

Durable success and complication rates have recently been more convincingly described in relatively large series compared to historical small series and case reports. Wound complications are common postoperatively (33–75%) and range from a focal wound separation with need for wet-to-dry dressings to wound abscess or complete wound dehiscence requiring reoperation. More substantially elevated body mass index (BMI) leads to more frequent wound complications. The general medical condition that accompanies morbid obesity and buried penis also leads to postoperative complications leading to occasional intensive care unit admission. Success rates, defined as the lack of need for subsequent surgical intervention for penile unburying, has been reported to be 88–91% in two of the largest published series [5, 12, 13, 16] (Table 56.2).

Case reports and the theoretical risks associated with LS raise concern for a higher risk for penile squamous cell cancer in adult men with acquired buried penis. Abdulla et al. describe a patient who had undergone neonatal circumcision but subsequently developed invasive squamous cell carcinoma in the setting of a buried penis. Manwaring et al. noted a similar phenomenon in two patients that had also had neonatal circumcision. LS has a known increased risk of squamous cell carcinoma and experts in the field advocate for biopsy at the time of stricture repair if LS is present [24, 30, 31].

Table 56.2 Contemporary series success rate and complications

Contemporary adult-acquired buried penis case series (2008–2019)					
Series	Patients (n)	Success rate (%) ^a	90 day complications (%)		
			Overall	Clavien 1-2	Clavien ≥ 3
Pariser et al. [16]	64	91	65	42	23
Hampson et al. [13]	42	NR	33	NR	NR
Tausch et al. [5]	56	88	NR	NR	NR
Voznesensky et al. [12]	12	NR	75	75	0

^aSuccess rate – Durable unburying of the penis without need for subsequent procedure
NR not reported

56.5 Contemporary Surgical Management

Donatucci and Ritter published an algorithm for the surgical management of AABP in 1998. Their initial systematic description of etiology, comorbidities, and surgical technique was forward thinking. Their algorithm was based on the presence or absence of an impinging suprapubic fat pad and the viability of penile skin. In extensive cases of buried penis in which there was a prominent suprapubic fat pad and loss of penile skin they advocated for escutcheonectomy and STSG. In more restricted cases where they felt the penile skin was viable they performed primary closure or z-plasty with native skin [32]. Subsequent authors have reiterated the importance of the need for escutcheonectomy and viability of penile skin as the primary determinants of surgical approach. A large escutcheon or lymphoedematous tissue that requires resection is often apparent intraoperatively but the viability of penile skin is often only known intraoperatively.

56.5.1 Cicatrix with Viable Penile Skin

Cicatrix formation after circumcision or due to LS is the most frequently described cause of buried penis with preserved penile skin. A less common etiology is dysgenetic dartos tissue with bunching of the skin distally. If uncircumcised there is the appearance of a short phallus with redundant foreskin. Xu et al. describe correction of this uncommon problem by fixating Buck's fascia to the scrotal dermis at the base of the penis. They accomplish this feat by degloving the penis and then making a small vertical z-plasty incision at the ventral base of the penis. The degloved penis is passed through this incision, fixed to the scrotum and then the penile skin is passed back over the penis and affixed to the proximal scrotal skin and the coronal sulcus [33].

Cicatrix formation with viable penile skin is a more common phenomenon and treatment beyond a dorsal slit necessitates local tissue rearrange-

ment. Described approaches include z-plasty when there is a longitudinal skin deficit or a ventral slit with scrotal flap (VSSF). Westerman et al. published a series of patients with a cicatrix and otherwise viable penile skin. As the name implies, the VSSF procedure is initiated with a vertical ventral incision through the cicatrix. The ventral skin defect created by release of the cicatrix is augmented by a penoscrotal z-plasty incision creating a well vascularized scrotal flap, including the underlying dartos fascia, to fill the ventral defect. To avoid the appearance of penile webbing the scrotal skin dermis is affixed to Buck's fascia at the base of the penis to create a "penoscrotal angle." Their 15 patient series with 12 month follow up quoted a 73.3% success rate as measured by patient satisfaction and need for subsequent surgery. Recurrence was managed with abdominoplasty and STSG [32, 34].

Caution must be taken in the case of comorbid obesity where penile skin is bunched dorsally. Many cicatricial scars are a result of circumcision or previous minimalist approaches to penile unburying in the obese patient. Recurrence is commonplace when adjunctive procedures are not conducted to correct penile skin bunching.

56.5.2 Cicatrix with Nonviable Penile Skin

Correction of penile burying when there is a cicatrix and minimal remaining penile skin is most often managed with resection of the dense fibrous tissue burying the phallus, penile degloving, and STSG. An alternative method to correct large penile skin defects without the need for STSG is a two-stage procedure in which penile skin is resected and the penis is temporarily wrapped in the scrotum. A ventral scrotal incision is made and the scrotal skin is wrapped around the penis and reopposed in the dorsal midline of the penis. In 3–6 months when the dorsal skin has had a chance to neovascularize the scrotal skin is tubularized ventrally. Benefits include the lack of STSG and a sensate mobile skin due to the presence of transposed dartos. However, the skin will be hair bearing [3, 35].

56.5.3 Escutcheon or Lymphedema with Viable Penile Skin

Surgical management of an escutcheon with liposuction has been attempted in the setting of viable penile skin. In general use has been limited to less severe cases of overweight but not morbidly obese patients. In a series of 10 patients the mean amount of adipose tissue resected was 495.5 ml. This provided a 1.1 cm increase in penile length that the authors reported as largely satisfactory to patients and statistically significant. Suggested adjuncts to improve outcomes include division of the suspensory ligament of the penis to provide increased penile length and anchoring of the pubic and penile skin to the underlying rectus fascia [36–38].

Most high volume surgeons treating patients with substantially elevated BMIs agree that suprapubic lipectomy or escutcheonectomy with tacking of the skin to Buck's fascia or the pubis is a necessary step for durable results. This is especially true in advanced cases where a cycle of chronic moisture and infection has led to edema and fibrosis of the surrounding skin [4, 13].

56.6 Escutcheon or Lymphedema with Nonviable Penile Skin

When there is a large escutcheon or extensive scrotal lymphedema and penile skin is nonviable an extensive procedure is needed for durable penile unburying. Elements of reconstruction include escutcheonectomy, scrotoplasty, and penile STSG.

The patient is prepped and draped in the dorsal lithotomy position ensuring the lateral thigh is prepped and exposed if needed for a STSG donor site. A foley catheter is placed at the outset or after the glans has been exposed.

The procedure is begun with a dorsal slit to expose the glans. Retraction for subsequent penile degloving is aided by placement of a glans stitch. Care is taken to deglove from the coronal sulcus to the base of the penis where the suspensory ligament of the penis attaches to the pubis. Leaving a remnant penile skin at the corona can lead to a ring of edematous tissue after repair.

The margins of escutcheon and scrotal resection are marked in an inverted triangular fashion with a transverse incision on the escutcheon and the apex of the triangle at the base of the scrotum. Care is taken to ensure the waistline sulcus (condensation of Scarpa's fascia adherent to the rectus that separates the abdominal pannus from the escutcheon) is preserved and there is enough escutcheon tissue to reach the base of the penis. The escutcheon is resected to the level of the abdominal wall fascia creating a vascularized suprapubic flap. The spermatic cords are often encountered and can be secured with penrose drains. The incision is carried onto the scrotum in the midline bilaterally. At this point the specimen, including the fibrotic penile skin, can be detached. Consideration can be given to harvesting a STSG from the resected escutcheon if the skin appears healthy for grafting [39].

Reconstruction after resection is accomplished by securing the suprapubic flap to the underlying rectus fascia and pubic symphysis with multiple interrupted absorbable sutures to prevent seroma formation and flap migration. The scrotal skin is reapposed in the midline and the suprapubic flap and scrotal skin is secured circumferentially to the base of the penis with absorbable braided sutures. A collar of scrotal and escutcheon skin can be advanced onto the penile shaft circumferentially beyond tacking sutures to prevent a cleft at the base of the penis. STSG is sutured circumferentially to the collar to created continuous skin coverage (STSG management described in detail in the following section). The scrotal and suprapubic incisions are closed in layers most commonly with absorbable braided sutures. Consideration can be given to monofilament retention sutures if there is concern for tissue on tension. Closed suction drains under the suprapubic flap and in the scrotum should be employed [29].

Postoperative outcomes can be dramatic with durable unburying of the penis and restoration of urinary hygiene and sexual quality of life (Fig. 56.3) Multiple surgical videos have recently been published highlighting these principles (Table 56.3).



Fig. 56.3 Paired preop, 3-month postop, and 12-month postop surgical outcomes. (a) Preop, (b) 3-month postop, (c) 12-month postop

Table 56.3 Surgical videos detailing the steps of escutcheonectomy and STSG for adult acquired buried penis

Surgical videos describing repair of buried penis with escutcheonectomy and penile STSG	
Figler and Voelzke	Plast Reconstr Surg – 2015, 136(5):1090–2
Fuller and Rusilko	Urology – 2017, 108:237–8
Jun and Santucci	BJU Int – 2018, https://doi.org/10.1111/bju.14230 .

56.6.1 Split-Thickness Skin Graft

Split-thickness non-meshed skin graft has been widely advocated for penile coverage when necessary to provide a hairless cosmetic and functional outcome. Care is taken after the decision has been made to resect the penile skin to include all tissue up to the coronal sulcus to prevent post-operative lymphedema of remnant skin. Special

attention is given to application of the graft while the penis is on full stretch to prevent graft folding and loss of contact with the underlying tissue. Typical STSG for penile application is harvested by a dermatome with a thickness between and 0.012 and 0.018 inches [6, 7].

Described STSG donor sites in AABP are the lateral thigh and the resected escutcheon when applicable. Donation from the escutcheon prevents the morbidity of a donor site. Some authors have expressed concern the resected skin from the escutcheon is suboptimal due to prolonged edema and inflammation that could affect graft take and promote future contracture. When the lateral thigh is used the site can be covered intraoperatively with thrombin or epinephrine soaked telfa dressing and postoperatively covered for the first 3–7 days with iodine impregnated incision drape with a small tunneled closed suction surgical drain [6, 8] (Fig. 56.4).

The traditional care of STSGs are bolster dressings that are removed after inosculation is established. Permanent sutures at the coronal sulcus and base of penis are used to secure bulky layered dressing to promote graft apposition. The inner layers are non-adherent materials such as a petroleum gauze dressing or mineral oil soaked cotton balls followed by fluffed rolled gauze. Varied periods of postoperative immobility have been advocated after penile STSG including bed rest for up to 5 days postoperatively [6]. Sexual activity should be avoided for 6–8 weeks to avoid graft sheering [4].

56.6.2 Negative Pressure Dressings

Negative pressure dressings have been studied extensively in the plastic surgery literature in relation to STSGs. Proposed mechanisms for

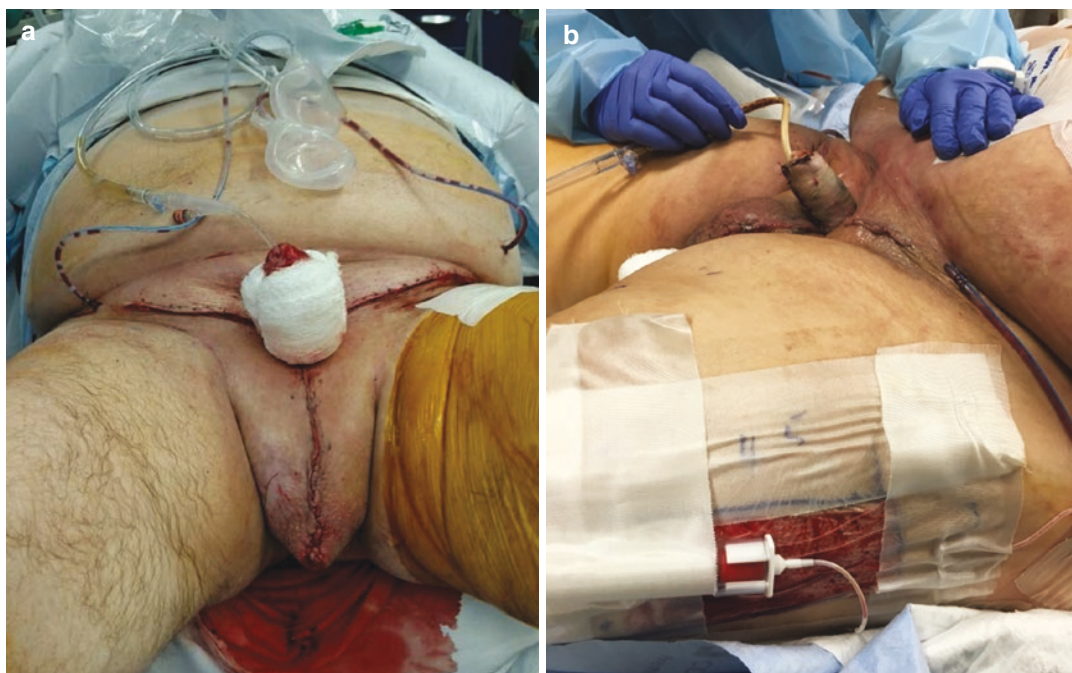


Fig. 56.4 (a) Triangulation of abdominal and scrotal flaps to the base of the penis. The penis is wrapped in a bolster dressing with vaseline impregnated gauze at the base followed by wrapped kerlex. The dressing is secured

in place with bolster sutures from the corona to the base of the penis. (b) STSG donor site managed with adherent dressing and small negative pressure drain

improved graft take have been described. First, negative pressure dressings promote microcirculatory flow and stimulate angiogenesis. Second, graft lift is prevented by evacuation of edema, graft bed exudate, and hematoma. Finally, graft shear from the graft bed is also limited by the immobility provided by negative pressure dressings. Surgeons have applied this principle successfully to STSG of the penis and find it especially useful given traditional difficulties in applying reliable circumferential pressure. Adjuncts to the technique include intraoperative erection induction by prostaglandin injection to ensure a well stretched graft and daily tadalafil to promote penile engorgement to prevent contracture [9, 40, 41].

In addition to use for STSG, negative pressure dressings have been investigated in high risk wounds in multiple settings including pressure ulcers, vascular groin wounds, abdominal hernia repair, and in colorectal surgery. Trials are ongoing to evaluate their role in application over closed wounds to limit the risk of wound dehiscence and surgical site infection (SSI). Large animal models suggests negative pressure dressings increase blood flow, collagen deposition and limit wound fluid collection with extensive incisions associated with dead space. The role of negative pressure dressings for closed escutcheon and scrotal incision is likely relatable to this literature and will be clarified by ongoing trials [42, 43].

56.7 Quality of Life

The adverse effects of AABP are both physical and psychological. The combined result of diminished or absent sexual function, lower urinary tract symptoms, poor hygiene with social isolation, and pain from chronic local moisture and skin breakdown is frequently depression. A disease specific quality of life instrument that measures all facets of AABP sequelae does not yet exist. Authors have employed multiple instruments from urologic conditions with similar

elements, bariatric surgery, and depression questionnaires for evaluation of quality of life changes with surgical treatment.

56.7.1 Sexual Outcomes

Globally, men note an improvement in their ability to function sexually and confidence. Sexual function has been shown to reliably improve with surgical management of AABP. Rybak et al. noted a mean 7.7 point improvement in the International Index of Erectile Function (IIEF) scores post operatively. In addition to function, men also take substantially more pleasure in their sex lives postoperatively. Patient should be cautioned that sexual function will not return to their perceived historic baseline in many settings. Voznesensky and colleagues found 58% and 25% of patients continued to have frequent or occasional difficulty with sexually activity respectively [12, 17, 44, 45].

56.7.2 Urinary Outcomes

Overall measures of urinary bother after operative management of AABP improved significantly as measured by the EPIC questionnaire. Specifically, men are satisfied with their improved ability to stand during urination and improved urinary hygiene. Hampson et al. found approximately half of men could urinate while standing preoperatively and two-thirds had issues with urinary genital hygiene both of which substantially improved postoperatively [12, 13, 17].

56.7.3 Overall Quality of Life

Perhaps most importantly, despite frequent prolonged convalescence and wound complications 85–92% of patient report they would repeat their decision to undergo surgical intervention [12, 13] (Table 56.4).

Table 56.4 Series evaluating quality of life outcomes after surgical management of adult acquired buried penis

Quality of life outcomes							
Series (year)	Instrument	Patients (n)	Mean follow-up (months)	Outcomes (% improvement), (NR = not reported), (I = improved but % not reported)			
				Sexual	Urinary	Hygiene	Would have surgery again
Theisen et al. [17]	EPIC – sexual and urinary domains	16	13	94	83	NR	NR
Voznesensky et al. [12]	Modified Post-Bariatric Surgery Quality of Life Questionnaire (PBSQoL)	12	31	41	91	100	92
Hampson et al. [13]	Institutionally developed questionnaire	27	39	I	I	I	85
Hughes et al. [45]	Changes in sexual function questionnaire (supplemented)	9	NR (range 12–84 months)	I	I	I	NR
Rybak et al. [44]	European Organisation for Research and Treatment of Cancer 15 QOL, International Index of Erectile Function (IIEF)	11	NR	91	I	NR	NR

56.8 Conclusions

Adult acquire buried penis represents substantial morbidity to patients and a surgical reconstruction challenge to urologists. Etiologies include morbid obesity, post-circumcision cicatrix formation, and genital lymphedema. There is an increasing incidence of AABP worldwide as a result of the growing epidemic of morbid obesity. Surgical principles in contemporary large published series include resection of the suprapubic fat pad (escutcheon) and use of split-thickness skin grafts due to genital skin loss from penile burying. Patient habitus, and accompanying comorbidities such as diabetes and peripheral vascular disease, result in relatively frequent wound complications. Consistently demonstrated improvements in urinary, sexual, and hygiene symptoms and overall quality of life validate assuming the risks and challenges of surgical repair.

Key Summary Points

- Patient with adult acquired buried penis often have multiple comorbidities and should be evaluated and optimized preoperatively
- Adult acquired buried penis is often found in conjunction with urethral stricture disease
- Severe cases require escutcheonectomy, scrotoplasty, and penile split-thickness skin grafting
- Wound complications are common and negative pressure dressings for both surgical incisions and for split-thickness skin grafts may be helpful
- Repair of adult acquired buried penis is associated with significant improvements in quality of life and patients would often undergo the surgery again when queried

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Scrotal Reconstruction and Testicular Prosthetics

57

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and Jay Simhan

57.1 Scrotoplasty for Penoscrotal Web (PSW)

Penoscrotal webbing (PSW) is a condition without a universal consensus as to how it should be defined. In general, it is an attachment of the scrotum to the ventral shaft of the penis which is distal enough to significantly reduce the penoscrotal angle (Fig. 57.1a). Though it can be con-

genital, most PSW are iatrogenic after circumcision. PSW can affect penetration during intercourse, affect perception of penile length, and, as a result, negatively influence sexual self-esteem [1]. There is a 4% prevalence of PSW in pediatric populations, where the majority of PSW research has focused [2]. A grading scale for PSW has been proposed by El-Koutby and Amin: grade 1 where webbing extends to proximal third

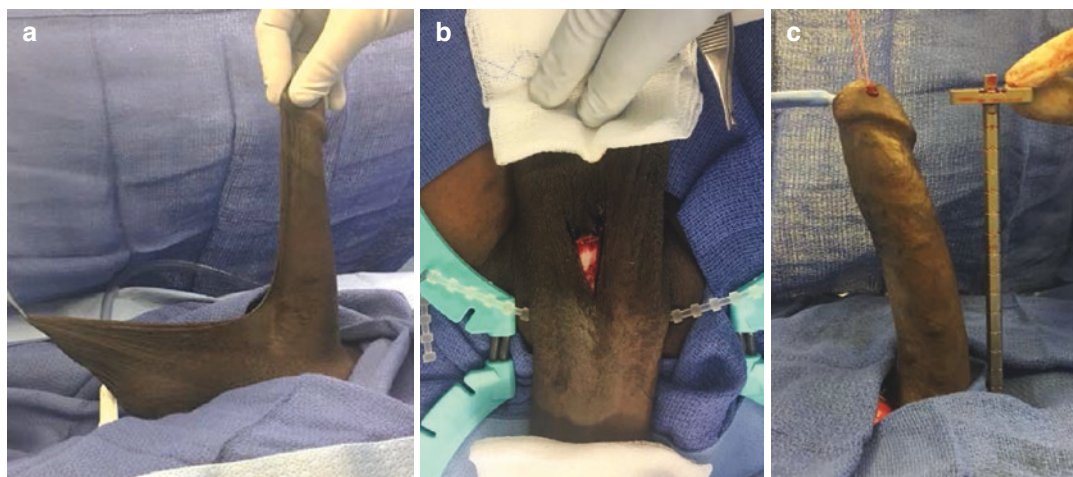


Fig. 57.1 Penoscrotal web (PSW). (a) Prior to the OR, PSW can be appreciated between the scrotum and proximal ventral shaft. (b) V-Y scrotoplasty flap – excess tissue

is excised and the tissues are mobilized caudally in V-formation. (c) PSW status post-operative intervention

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of penile shaft, grade 2 extends to the middle third, and grade 3 extends to the distal third [2].

Increased attention has been paid to adult PSW within the literature due to its role in erectile dysfunction and prosthetic surgery. One of the most common complaints following penile implantation is penile shortening after device implantation, despite preoperative counseling on penile stretch length correlating with post-implant erection length [3, 4]. As a result, urologists have investigated methods to increase perceived penile length via ventral phalloplasty and scrotoplasty [5, 6].

Accordingly, there are a variety of techniques to correct PSW. Most simplistically, PSW can be corrected by making a horizontal incision across the scrotum and closing it longitudinally [7]. Patients undergoing penile prosthesis implantation who also have PSW can safely undergo concomitant PSW correction [8]. Carrion et al. described one such repair, using opposing curved “checkmarks” to excise redundant scrotum near the penoscrotal junction—the curved incision helps to decrease the amount of redundant tissue during closure [9]. The investigators reported high patient satisfaction after simultaneous penile prosthesis and PSW correction, with a majority (84%) reporting increased perceived penile length [8]. We caution any urologist who attempts such simultaneous repair to not be over-zealous with the degree of scrotoplasty as any tension on the wound increases chance of wound breakdown and compromise of the implanted device.

A more complicated scrotoplasty involves single- or double-Z plasty, which can increase the longitudinal length of skin and make penile length appear longer. In this technique, the main limb of the Z-plasty is centered on the median raphe and all arms off of this should be made at the same angle and at the same length [10]. A criticism of the Z-plasty technique is that it has the potential for increased wound breakdown as the arms of the “Z” carry significant tension which can potentially decrease blood supply.

Another complex scrotoplasty is the V-Y advancement flap. Unlike the Z-plasty, there is less tension in the V-Y advancement, which better maintains the blood supply. The V-Y advance-

ment involves making a V-shaped incision whose apex is at the penoscrotal junction. This is then mobilized and the apex of the “V” is partially closed so that a Y-shape is formed by the suture line [11]. We perform a variation of the V-Y scrotoplasty called the V-Y flap scrotoplasty in which a V-shaped incision is made with the apex towards the urethral meatus (Fig. 57.1). The V is then mobilized caudally, with redundant tissue excised, and then closed longitudinally in three layers—two running layers in Dartos with 3–0 Monocryl (Ethicon, Inc., Piscataway, NJ, USA) suture and one layer in the skin with interrupted 3–0 Chromic catgut (Ethicon, Inc., Piscataway, NJ, USA) suture with great care taken to have a tension-free skin closure. The interrupted catgut skin closure leads to less wound breakdown as the tension in the skin closure is spread across multiple sutures.

57.2 Scrotal Debridement: Etiologies

Scrotal debridement is necessary for a wide range of conditions including: trauma (thermal, penetrating, and blunt), infectious (Fournier’s gangrene), cancer, hidradenitis suppurativa, and others. Regardless of cause, reconstruction of the scrotum can be quite complex, particularly if a good cosmetic outcome is desired.

Genitourinary trauma is found in up to 10% of all patients with other trauma, with testicular/scrotal trauma encompassing 27.8–68.1% of those cases [12, 13]. Trauma can range from blunt to penetrating, as well as the less commonly seen bites and burns. The vast majority of scrotal trauma, reported up to 85%, is blunt, with the remaining 15% represented by penetrating trauma: 55% by gunshot wounds, 42% by stab wound, and 3% by bite wounds [14]. Burns are far less frequent as the male genitals are mobile and commonly protected anteriorly and posteriorly by overlying clothing and laterally by the thighs. When looking at patients who present to burn centers, only 2.8–13% have genital burns caused by flames (24–77%), hot liquids (15–64%), and chemicals (8–16%) [15, 16].

Fournier's gangrene is a necrotizing infection of the genitals and perineum, with a reported incidence of 1.6/100,000 males [17]. It is ten times more common in men than women [18]. Pathophysiologically, the bacteria causing the infection (commonly polymicrobial) release toxins which break-down soft tissues and cause arterial thrombi which further leads to tissue breakdown by causing localized tissue hypoxia/ischemia [19, 20]. The infection rapidly spreads and the typical patient is immunocompromised via conditions such as HIV, diabetes mellitus, alcoholism, chronic steroid/immunosuppressant use, chemotherapy recipients, alcoholism, and blood dyscrasias [19–21]. Diagnosis is clinical and based on history and physical exam, with the classical physical exam finding of crepitus, found in 64% of patients, indicating presence of subcutaneous gas formed by the bacteria [22]. Diagnosis can be augmented with lab-work, scrotal/perineal ultrasound, and CT of the pelvis – but should not delay definitive management when clinical suspicion of the diagnosis is high.

Hidradenitis suppurativa is a disease of chronic inflammation in apocrine glands of the axilla, groin, and gluteal clefts, and can be quite painful

(Fig. 57.4). It commonly starts as small focal areas of erythema and nodularity and can eventually coalesce into large abscesses with sinus tracts, lymphedema, and fibrosis. Due to the embarrassing nature of the disease, patients often forego evaluation and treatment, and incidence is only reported to be in 1–4% [23]. When found in the groin/perineum, which occurs in 24% of cases, the urologist is commonly involved in the care of the patient, and even after resection, recurrence has been reported as high as 75% [24]. Risk factors include obesity, family history of hidradenitis suppurativa, and tobacco use [25].

Lymphedema of the genitals can be range from mild to extreme, such as the cases in elephantiasis (Fig. 57.2) and is characterized by duration, location, and underlying pathology. Depending on the etiology, the edema can be slow or rapid in progression. It can be the result of infection, radiation, neoplasm, iatrogenic (as seen after lymph node dissection), and congenital [26, 27]. Bladder, prostate, penile, colorectal, gynecologic, and hematologic cancers can all infiltrate and engorge inguinal lymphatics and cause obstruction/dilation of distal blood vessels. The risk of lower extremity lymphedema is

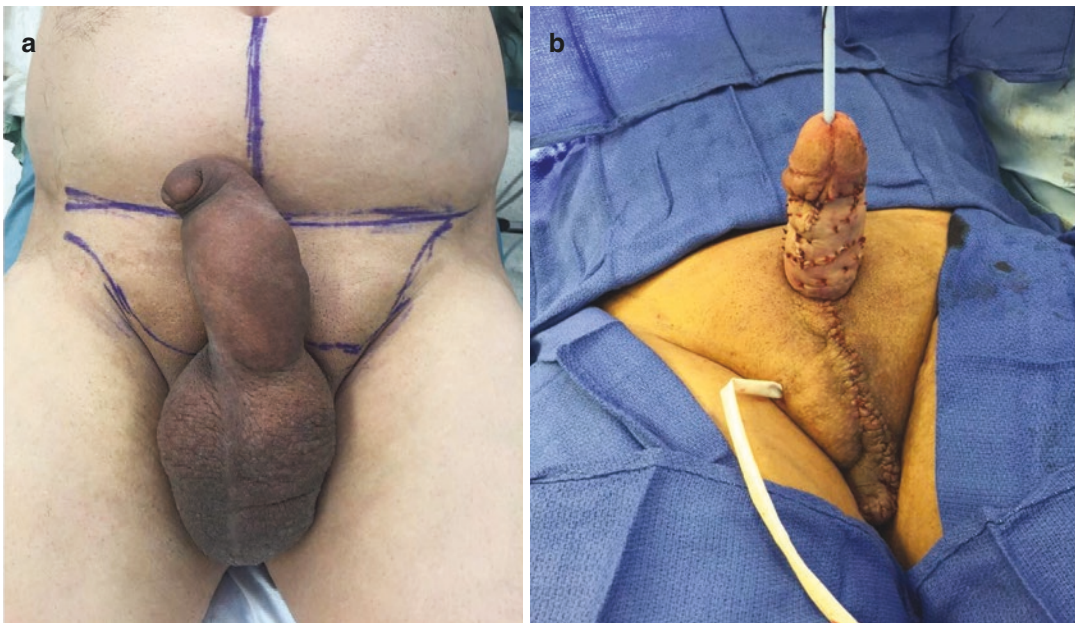


Fig. 57.2 Genital lymphedema. (a) Lymphedema of the penis and scrotum. (b) Immediately status post excision of edematous tissue and split thickness skin grafts

15–30% after prostatectomy with pelvic lymph node dissection, of which 50% of those affected will have involvement of the penis/scrotum [28]. Physical exam and history are the mainstays of diagnosis, but augmentation with ultrasound, CT, MRI, or lymphoscintigraphy may be necessary in exposing the underlying etiology.

57.3 Scrotal Debridement: Treatment

When treating these conditions, sufficient scrotal skin must be debrided with the etiology dictating whether the reconstruction be immediate or delayed. In Fournier's gangrene, which has a 20–40% mortality rate in historical studies, the debridement must be early and aggressive [17]. Prior to resection, hemodynamic monitoring, intravenous fluids, and broad-spectrum antibiotics must be initiated, ensuring that gram positive, gram negative, aerobic, and anaerobic bacteria are covered. At our institution, we use a triple combination of gentamicin, clindamycin or metronidazole, and a third generation cephalosporin such as ceftazidime or ceftriaxone; infrequently we will add antifungal coverage. After initiation of the above, the patient undergoes surgical debridement of non-viable tissues, with the presence of bleeding as the determinant of adequate resection. We recommend at least one "second look" surgery, though frequently patients require multiple debridements with trips to the operating room so that patient can be thoroughly examined under anesthesia [29]. A multidisciplinary team may be required with general surgery should the debridement extend onto the patient's abdomen or necessitate a loop colostomy should the debridement extend posterior enough to warrant one so that the wound bed is not exposed to feces. Orchiectomy during these resections is very rare due to the robust blood supply to the testicles [30, 31]. Should the resection of scrotal tissues be so extreme that there is insufficient space for the testicles, thigh pouches can be created on the anteromedial thigh at different levels to prevent rubbing during movement of the lower extremities. However, we feel

that the use of thigh pouches is more a historic maneuver that is not necessary as it can be uncomfortable to the patient during ambulation. We instead elect to keep the testicles wrapped with saline gauze or VAC dressing as part of the remaining wound bed during the immediate post-operative period.

After excision and debridement, local wound care is extremely important regardless of modality used, whether it be wet-to-dry dressings that are changed two to three times daily or negative-pressure dressings with vacuum-assisted closure (VAC) devices changed every 2–3 days. At our institution we use wet-to-dry dressings until all planned debridements are completed. Depending on patient comfort and the extent of resection, patients may require repeated exams under anesthesia for proper wound inspection and VAC changes. We recommend continuous negative pressure dressings at 125 mmHg, which can prove difficult to maintain due to the contour and crevices of the genitals which complicate maintaining a vacuum seal. We liberally utilize wall suction if the vacuum pump is unable to maintain the seal (as could be the case due to the aforementioned crevices). Some have even advocated making a basket out of the sponge to better cover the scrotum [32]. Borgquist et al. examined the effects of negative pressure on fluid evacuation and wound contraction, and found that although 75 mmHg has superior wound contraction, 125 mmHg offers maximal fluid evacuation [33]. Others have demonstrated no difference on wound healing between 75 and 125 mmHg [34]. VAC therapy is advantageous over simple wet-to-dry dressings due to a faster rate of granulation formation, fewer dressing changes, lower microbial burden, and overall accelerate wound healing [35–38].

Closure of the wound bed can be difficult as serial debridements might leave a resultant defect that is substantial (Fig. 57.3). Closure should not be attempted until no further debridements are required and the patient is stabilized clinically. We commonly wait 7–10 days prior to any skin grafting procedure at our institution; however, at other institutions reconstruction might acceptably be handled by plastic surgery.

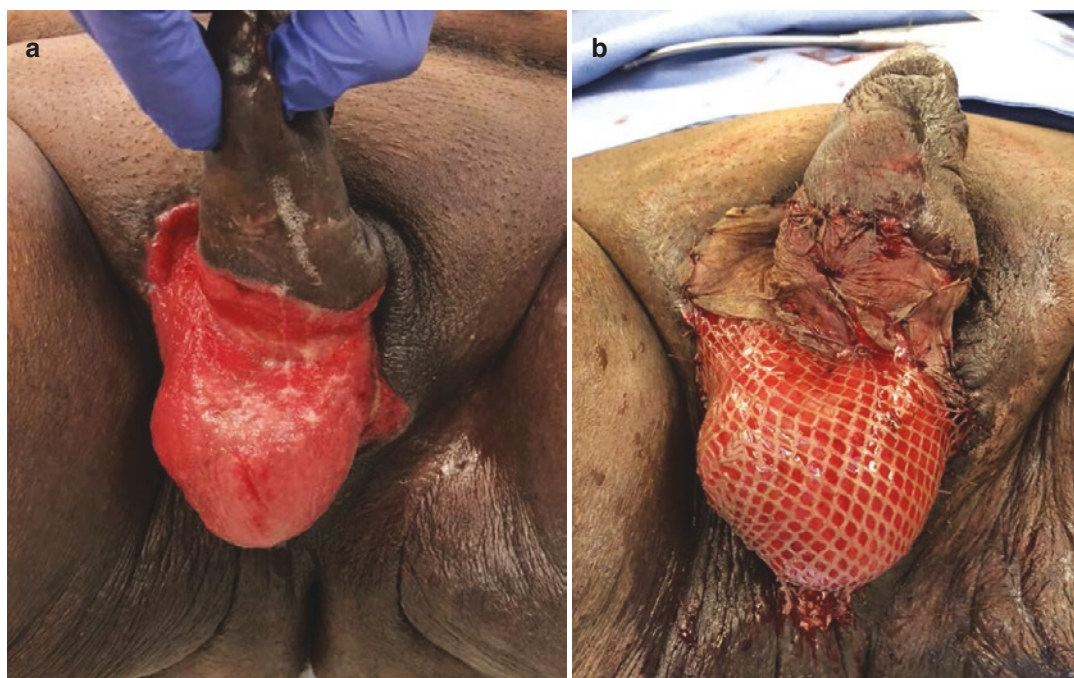


Fig. 57.3 Fournier's gangrene. (a) A large scrotal defect after surgical debridement of Fournier's gangrene. This is after several days of a negative pressure dressing, result-

ing in healthy granulation tissue. (b) Immediately post-operatively from split-thickness skin grafting of the scrotum

Unlike Fournier's gangrene patients where the focus of treatment is entirely on the groin/genitals, blunt and penetrating traumatic injuries to the genitourinary system are commonly found on secondary or tertiary survey after the patient has been stabilized and otherwise worked up via ATLS protocol. Once identified, scrotal wounds should be irrigated with normal saline, any debris removed, and the patient should receive antimicrobial and tetanus prophylaxis, if indicated, and not already given as part of the trauma workup. AUA Urotrauma guidelines indicate that any burn, penetrating trauma, or infection of the scrotum go to the operating room for exploration and debridement [39]. Clearly, if there is a Dartos violation there should be a higher suspicion of missed testicular injury, which, if not addressed promptly, can lead to hematoma formation, orchalgia, or even atrophy/reabsorption of the testicle. We recommend scrotal ultrasound for blunt trauma to rule-out any testicular injury and operative exploration for any penetrating injury to the scrotum that violates the Dartos layer.

Sonographically, the blunt injured testicle will be heterogeneous and have a loss of contour ordinarily seen in healthy testicles [40].

Management of burns to the perineum should be managed as burns elsewhere on the body, with removal of contaminated clothing, cooling of the affected areas to prevent spread of the burn, and local wound care. Like Fournier's gangrene management, any tissue deemed non-viable should be debrided until bleeding tissue is apparent. However, some studies have shown that expectant management of genital burns without wide debridement can be successful in 61–90% of patients [15]. Urinary and fecal diversion to prevent wound infection or promote wound healing is controversial and not necessary in many instances [41]. Peck et al. examined nearly 2000 patients presenting to a regional burn center, and none required indwelling urinary catheter outside of the initial resuscitation period [42]. At our institution, we only use urinary/fecal diversion in cases of aggressive, refractory Fournier's gangrene that require extensive and multiple debridements.

Lymphedema is managed conservatively at first, with the focus of treatment being the disease process causing the lymphedema. While the underlying process is being treated, the scrotum can be elevated and compressed to help aid in passive drainage of the scrotum with any lymphorrhea treated locally to prevent tissue breakdown from moist conditions. Garaffa et al. examined 90 patients with lymphedema and found that 64% were successfully managed non-operatively [27]. Should the patient not respond favorably to local, non-operative management, surgical resection of the edematous lymphatic channels can be accomplished by excision of the dermis and epidermis through which the lymphatics travel. In a similar manner, hidradenitis suppurativa can be managed conservatively with antibiotics, immunosuppressants, and local drainage of small abscesses; however, should these measures fail, patients may require an excision of the affected tissues (Fig. 57.4). Kagan et al. published a decade-long study, looking at management of patients with hidradenitis suppurativa and found that nearly 2/3 of patients required >1 incision and drainage of abscess and > 90% required long-term antibiotics [43]. Newer therapies are currently looking at targeted immuno-

therapy for treatment of hidradenitis suppurativa, including inhibitors of tumor necrosis factor (TNF), IL17, IL1, IL12/23, and PDE4 [44, 45]. As it currently stands, only adalimumab, a TNF inhibitor, is an FDA approved biologic for the treatment of hidradenitis suppurativa [45]. There have been promising studies looking at surgery followed by adjuvant biologic therapy [46]; however, until more clinical data in humans emerge, surgery will continue to be a standard of care treatment once conservative measures fail [47].

After resection of the scrotum is complete and there are no further plans for resection depending on the etiology, the closure of the scrotum must be assessed whether it is via primary closure or via skin grafts/flaps. In our experience, we have found that as long as the tissue is healthy and not involved with the resected pathology that only 40–50% of the scrotum is necessary for primary closure. This has been supported in the literature, in which Alikov et al. retrospectively looked at 333 patients undergoing scrotal reconstruction for Fournier's gangrene and found that only 50% of the scrotum was needed to prevent the use of STSG [48]. We recommend using two to three layers of closure below the dermis with absorbable suture before closing the skin. Use of a

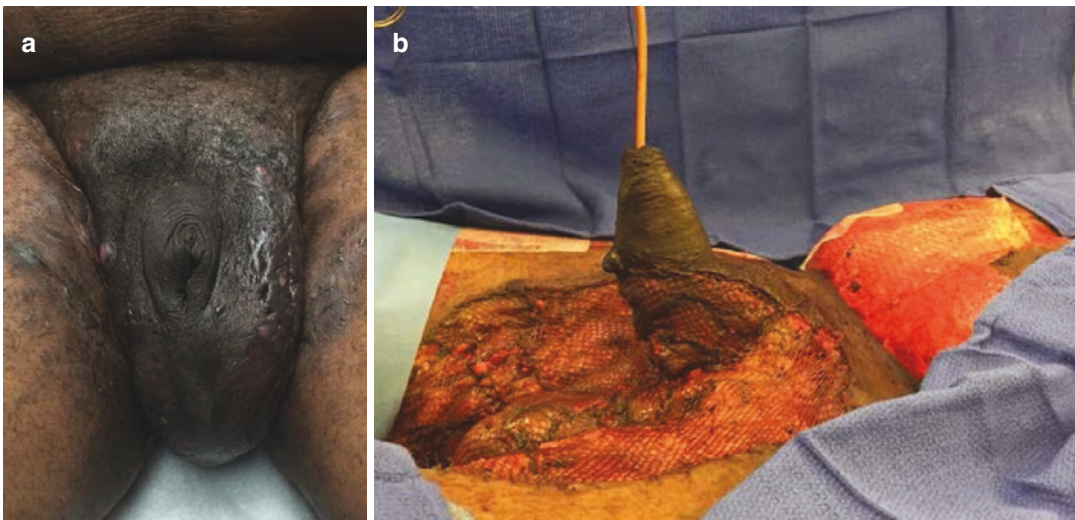


Fig. 57.4 Hidradenitis suppurativa. (a) Hidradenitis suppurativa of the penis, scrotum, and thighs refractory to conservative therapy. (b) Immediately post-operatively from

split-thickness skin grafting from the abdomen and lateral thighs. Meshing 1:1.5 ratio is used to minimize the amount of tissue harvested in order to cover the recipient site

closed suction drain for 3 or more days is also recommended, particularly in cases where there is less viable scrotum to accommodate any post-surgical fluid collection.

57.4 Scrotal Debridement: Reconstruction via Skin Grafts

When debridement encompasses >60% of the total scrotal tissue, the scrotum needs to be reconstructed, which can be accomplished via several techniques: split-thickness skin grafts (STSG), full-thickness skin grafts (FTSG), or myocutaneous/fasciocutaneous flaps [49–53]. Reports of using synthetic grafts in combination with STSG have been demonstrated with good effect [54]. Regardless of the reconstructive option chosen, the long term outcomes appear to be similarly high between all approaches, with risks and benefits of any given approach guiding surgeon choice [55]. When considering reconstruction, the time, technique, effect on sexual function, and after-care must be contemplated. Reconstruction, at least in cases of infectious or necrotic debridements, should always be delayed until there are no further debridements planned. When debridement occurs for cases of hidradenitis or lymphedema, concomitant STSG can be performed at the time of the index operation.

There has been some debate as to whether or not skin grafts or flaps provide superior temperatures for spermatogenesis, and to date there have been no well-powered studies in humans investigating which technique provides superior spermatogenesis. A study by Demir et al. that compared grafts vs flaps in rats demonstrated that the flap group had similar Johnsen scores for spermatogenesis as controls whereas the skin graft group had lower scores [56]. Contradictory to this, Wang et al. found that flaps had lower spermatogenesis compared to baseline function [57]. More research is needed to directly compare fertility rates between the reconstruction techniques before a final verdict can be reached.

Choosing the technique to best reconstruct a patient depends on wound-type, patient fertility

goals, health of surrounding tissues, and surgeon comfort. We tend to use STSG for scrotal reconstruction at our institution as it has been tried and proven in a variety of conditions and is technically simplistic [25, 58, 59]. STSG, compared to flaps, offers a more natural appearance to the native scrotum especially when the graft is meshed, theoretically provides more appropriate temperatures for spermatogenesis, can be performed in a single stage, and results in minimal post-operative morbidity [53].

We tend to use the thigh as the primary donor site for STSG at the time of scrotal/penile reconstruction. In cases where the patient might require a larger area of reconstruction (such as buried penis, lymphedema, or extensive Fournier's gangrene debridement), the abdominal wall is another harvest site often utilized after the thigh donor has been exhausted. A pneumatic dermatome with 0.018 inch thickness is used to harvest the tissue at a 45° angle to ensure even depth. The graft is then meshed to give a ratio of 1.5:1, which not only aids in scrotal cosmesis long term, but also allows for smaller grafts to cover a larger surface area (Figs. 57.2, 57.3, and 57.4). For penile reconstruction, we do not recommend meshing as it has poorer cosmetic outcomes for the penile shaft and glans [60]. Whenever the dermatome is employed, mineral oil or other sterile lubricants should be used to prevent undue trauma to the graft and harvest site tissues. Prior to the application of any graft tissue, the testes should be appositioned using absorbable suture in the midline [61]. At our institution we use Vicryl for this purpose (Ethicon, Inc., Piscataway, NJ, USA). Suturing the testicles together prevents torsion and aids in cosmesis by helping develop a plane between the two halves of the new scrotum (Fig. 57.3).

We apply Artiss fibrin sealant (Baxter Healthcare, Inc., Deerfield, IL, USA) that is a long-acting agent, prior to application of the skin graft. The use of fibrin sealant aids in the setting of the graft and its adhesion to the testes [62–64]. Once in place, the edges of the graft should be stapled or sutured into place with fast-absorbable suture; we recommend interrupted 3–0 or 4–0 Chromic sutures along the graft edges (Ethicon,

Inc., Piscataway, NJ, USA). Historically, petroleum-based gauze dressings were used to bolster the grafts after application/fixation; however, we prefer to use negative pressure VAC dressings for roughly 3 days postoperatively. Several studies have supported the use of VAC dressings in skin grafting as they improve graft-take rate and accelerate healing compared to traditional dressings [65, 66]. Regardless of dressing choice, the patient should be on strict bedrest to prevent disruption of the graft during this very fragile time in the healing process. For donor sites, we recommend coating the wound beds with antibiotic ointment or mineral oil and covering them with Tegaderm dressings (3M, Maplewood, MN, USA) for as long as the dressing stays in place ideally several days to a week or more, but very commonly the dressing falls off after a few days. Large harvest sites have a tendency to ooze and more rapidly displace the Tegaderm dressing, and in these instances, we place a closed suction drain under the Tegaderm to wick away superfluous fluid. Once the initial harvest site dressings fall off or need to be changed for sanitary reasons, we apply antibiotic ointment or Xeroform gauze (Medtronic, Minneapolis, MN, USA) religiously to the donor site.

Even if all of the proper precautions are taken with superb post-operative wound care, complications can happen. The most common complication following skin grafting is wound breakdown, which most commonly is observed at the graft edges. Typically, we manage wound issues with topical agents, more diligent local wound care, and frequent office visits for wound checks. Through tedious attention to patient wounds following grafting, it is uncommon for patients to require return to the operating room.

Though not regularly performed at our institution, other reconstructive urologists advocate the use of flaps instead of skin grafts for large area defects of the genitalia. Flaps have been successfully used from the remaining local scrotal tissue (local advancement flaps) [55], rectus abdominus muscle [67], medial thigh [51, 52, 68], and lateral thigh [52]. Flaps maintain the original neurovascular supply and thus sensation can be preserved

in the flapped tissue. However, critics of flap reconstruction will point out that the operations take longer than STSG and that there are higher rates of wound infection [55]. Additionally flaps alone might not be able to cover a large-area defect of the genitalia and skin grafting might be called for regardless. As discussed earlier in this chapter, there are conflicting reports regarding which technique offers superior spermatogenesis and at this time there is no definitive study proving one method to be superior for preserving spermatogenesis [56, 57]. Both STSG and flaps have been shown to have good aesthetic outcomes [50].

57.5 Testicular Prosthetics

Male patients who lack testicles, either congenitally or as a result of trauma or surgery, have been known to report psychological distress regardless of age [69]. In these cases, a testicular prosthesis can be used to preserve the image of the male sexual body. Prostheses can also be used in cases of testicular atrophy and gender reassignment.

In the United States, there is only one FDA-approved device for testicular prosthesis, the Coloplast Torosa (Coloplast, Minneapolis, MN, USA). It is a silicone-coated saline filled device that was proven to be safe in a 5-year prospective trial at 18 different institutions [70]. Although other prosthetic devices are utilized throughout Europe and Asia, these have not been approved in the United States due to their silicone composition [71]. The Torosa comes in four sizes (extra small, small, medium, and large) corresponding to the fill-volume of the prosthesis. Note that when filling these devices, the injection port, located opposite the suture tab, can only be pierced five times. Studies have shown that the prosthesis can be implanted at the time of the index surgery without any increase in complication rate, as evidenced by Robinson et al. whom looked at 904 men who underwent radical orchiectomy [72].

Like other prosthetic devices, great care must be given to ensure that the prosthesis is placed aseptically to prevent device and wound infection. Local and superficial wound infections have been reported to be as high as 7.3% as evidenced

in a 2002 retrospective cohort study from UCLA [73]. Wound infection can lead to colonization of the prosthetic, and in up to 2.5% of cases, the graft can erode completely through the scrotum [74]. Though there is no one single method to achieve perfect sterility, we recommend pre-scrubbing the scrotum with chlorhexidine or betadine brushes, giving perioperative antibiotics, sterilizing the scrotum again with final skin prep, and irrigating the wound bed with antibiotic solution before and after the prosthesis is inserted. Perioperative antibiotic selection should adequately cover gram-positive, gram-negative, and anaerobic organisms. Many urologists will change gloves prior to handling the prosthesis. Another protocol to reduce wound infection outlined by Bodiwala et al. involves ensuring a negative urine culture preoperatively, having the patient bathe with chlorhexidine scrub before presenting to the operating room, shaving the genitals in the operating room, administering both systemic and local antibiotics, scrubbing the scrotum/incision site for 10 minutes with a betadine or similar scrub, and double gloving [69].

Many different approaches for testicular implantation have been described, including inguinal, trans-scrotal, and high-scrotal incisions. At our institution, given our adult patient population, we prefer to use a high scrotal incision. This incision affords us the ability to better control placement and suturing of the testicle into the desired position.

Many pediatric urologists tend to use the inguinal approach as it has the lowest risk of scrotal erosion [71]. In this method a semilunar incision is made at the attachment point of the scrotum to the remainder of the pubic skin. A plane is developed in the intrascrotal space for the prosthesis to be implanted. This technique has a lower reported rate of wound infection as the prosthesis does not touch the skin, has a shorter dissection tract than the standard inguinal approach, and the pubic hair easily hides the incision [75]. Other surgeons have adapted the inguinal incision technique by using a vaginal speculum to assist in placement of the prosthesis [76]. Simultaneous placement of testicular prosthesis can be done at the time of orchiectomy for

testis cancer or testicular torsion. Bush et al. described placing the prosthesis within the tunica vaginalis at the time of orchiectomy at time of orchiectomy for testicular torsion in a small ($n = 12$) cohort study [77]. Through this technique, there were no infectious complications at a median 5-month follow up and it has been since recognized as a way to ensure the testicle stays in the correct anatomical position while providing an extra barrier layer for infection.

Many patients are very satisfied with their prosthesis, as shown in self-esteem focused validated questionnaires [78–80], but there are some who experience complications, both physical/technical and in the overall cosmesis of the implant. The most common physical complications are extrusion (3–8%), infection (0.6–4%), chronic pain (1–3%), and hematoma (0.3–3%) [78, 81]. Some patients report being dissatisfied with the size, firmness, and position of the implant as some tend to migrate to a more cephalad position if not properly sutured into place [78].

57.6 Conclusions

Through the course of this chapter, we have described some of the more common scrotal reconstructive surgeries that are performed by urologists, ranging from simple scrotoplasties to complex scrotal reconstructions using skin grafting and prosthetics. We hope that with this chapter, the novice urologic surgeon can garner the appropriate insight into the surgeries along with their pitfalls and complications so that they feel more comfortable when performing the reconstructions.

Key Summary Points

- Closed-suction drains for scrotal wounds help prevent hematomas and thus might prevent unnecessary operating room “take-backs.”
- Even though the decision to return to the operating theater is a difficult one, should scrotal hematomas develop there

should be a low threshold for early re-operation.

- Fournier's gangrene should be managed with serial debridements. Even if the entire wound bed is excised to healthy tissue at the index surgery, we recommend at least one "second look" to ensure there is no further necrotic/infected tissue.
- In larger wound beds where a wound VAC is applied, the use of wall suction and frequent reinforcement of the dressing may be necessary to ensure adequate negative pressure is applied.
- We have had excellent skin graft take results with the use of fibrin glues. Our experience has noted that fibrin glues tend to aid in graft placement, adherence rates, and it further minimizes the need for excessive quilting sutures to tack the central portions of the graft.
- Breakdown of wounds and skin grafts can be managed non-operatively with local wound care and frequent wound checks in the office or at home by visiting nurses.

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Textbook of Male Genitourethral Reconstruction: Penile Augmentation, Fact or Fiction

58

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58.1 Introduction

Humans have been preoccupied with penile augmentation from time immemorial. Many techniques have been employed across many cultures and eras in the name of penile enlargement. In modern times, approaches have ranged from penile stretching to minimally invasive injectable therapies to more invasive surgical treatments such as augmentation phalloplasty. These interventions have sought to increase penile length, penile girth, or, in some cases, both.

Indications for penile augmentation are numerous. The majority of men seeking penile augmentation surgery have normal penile length and, therefore, likely suffer from ‘small penis syndrome’ or penile dysmorphic disorder [1–3]. While augmentation phalloplasty has been successfully utilized for penile dysmorphophobia, there is no consensus regarding appropriateness of penile augmentation for this indication [2, 4]. In contrast, penile augmentation is universally accepted as standard therapy for congenital conditions such as micropenis, particularly when medical therapy (i.e. testosterone supplementation) fails [5, 6]. Acquired conditions such as

penile scarring or malformation secondary to trauma, malignancy, or iatrogenic etiologies may also be amenable to penile augmentation on an individualized basis. Phalloplasty has unique considerations in the setting of Peyronie’s disease, penile implantation and gender confirmation surgery, and these topics will be addressed elsewhere.

Studies of penile augmentation have typically been limited by small sample size, poor methodology, and inadequate follow-up. Vardi et al. conducted a literature review and found just 34 of 176 identified papers met quality criteria for analysis with very few well-designed studies among them [7]. Many of these studies did not report essential outcomes such as objective measurements of change in penile size and subjective measurements of satisfaction. Even when reported, these outcomes are difficult to compare across studies, as methods for measurement vary greatly [8].

Poor study quality, coupled with the wide range of approaches and materials employed, has rendered it difficult to discern the true efficacy of penile augmentation procedures. This chapter aims to provide a brief review of historical and current approaches to penile augmentation, as well as a critical review of evidence regarding efficacy and complications.

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58.2 A Brief History of Penile Augmentation

The penis has figured prominently across cultures and throughout history [9]. Some of the earliest representations of the penis date back to the prehistoric era. Drawings, engravings, and sculptures of men from the Paleolithic period (38,000 to 11,000 BC) specifically depict the phallus [10]. Among statues recovered from Mesopotamian temples from the Neolithic period (9500 to 8500 BC) were those of the ithyphallic, or a statue with an erect penis [11]. Likewise, the recent discovery of cave drawings in southern Asia Minor demonstrated a large, erect penis, equal in size to the legs of the depicted male figure [12]. The geographic scope of these archeological findings suggests that even in prehistoric times, the penis had a universally central role within religion, art, and culture.

Ancient Greek, Roman, and Egyptian cultures were similarly fascinated with the large penis. The Greco-Roman fertility gods Pan and Priapus (from which “priapism” derives its name) were often represented on vase figures and in statues with erect, over-sized phalluses, indicative of virility and fertility [13, 14]. The Egyptian gods Geb and Min had large, erect penises, and the former was often depicted with a facial expression indicating a satisfactory grin [15]. The notion of a large penis retained a central role within the Judeo-Christian and Arabic traditions, where references and illusions to the penis can be found in the Old Testament and medieval Arabic literature [15].

In light of these profound cultural roots and favorable associations with the large phallus, it is no wonder that many different techniques have been devised for penile enlargement over the course of history. Some of the earliest attempts at penile lengthening consisted of traction therapy, practiced by Polynesians, Africans, Indians, and Peruvians, among others. Many different devices have been used, but all share the central

feature of applying weights to the penis in order to achieve stretching. While these approaches did not improve, and sometimes impaired, girth and function, they did succeed in stretching the penis to lengths of up to 55 cm [15].

Additional stretching techniques such as milking and jelqing similarly attempted to lengthen the penis through the diligent practice of repeated elongating maneuvers. Employed by the Sudanese, milking entails shaking the semi-erect penis up and down anywhere from 25 to 50 times, along with adjunct stretching maneuvers. Similarly, the Arabic jelqing method requires massaging the semi-erect penis from base to tip repeatedly, stopping prior to ejaculation and then restarting the process. Jelqing has been reported to increase both length and girth, and remains a common practice even in modern times, though scientific evidence is lacking (Fig. 58.1) [15].

Beyond traction and stretching maneuvers, a number of plant- and animal-based approaches have been utilized. Phytotherapy with substances such as ginseng and Ginko biloba was initially utilized in the Far East for penile enlargement, though limited modern evidence suggests that these agents have minimal efficacy on penile size or sexual function [16]. Materials such as paraffin and other oils were precursors to modern injectable therapies such as silicone. The Topinama Indians of Brazil went so far as to subject themselves to poisonous snake bites on the penis, which resulted in prolonged, albeit painful, penile swelling lasting up to 6 months [15].

Despite the uncertain efficacy of these varied ancient penile enlargement techniques, they serve as the foundation for some of the modern approaches to penile enhancement. The stretching techniques bear striking resemblance to the penile traction therapy and vacuum erection devices used for modern treatment of penile shortening in the setting of Peyronie’s disease [17]. Penile injection with paraffins and oils form the conceptual basis for modern techniques of penile fat transfer and injection of synthetic materials [18].



Fig. 58.1 Jelqing technique: “OK” grip followed by firm stroking maneuver from the penile base to distal shaft

**58.3 General Considerations:
Indications, Outcomes,
and Approaches**

As mentioned above, penile enhancement has been used in the setting of microphallus, fibrosis, trauma, and penile dysmorphia. Among these, microphallus is the most widely accepted indication, as men with this condition have a clear, objective penile deficiency and appear to have significant improvement with intervention [6, 19].

In contrast, consensus regarding appropriate indications for penile augmentation in the setting of penile dysmorphophobia is lacking. In the absence of specific guidelines, authors have utilized varied appropriateness criteria for penile enhancement procedures. Wessells et al. measured flaccid and erectile penile dimensions in 80 men and concluded that only men with flaccid length of less than 4 cm, representing two standard deviations below the mean, should be considered for augmentation procedures [4]. Spyropoulos et al. devised a patient questionnaire entitled, “Augmentation Phalloplasty Patient Selection and Satisfaction Inventory” (APPSSI) aimed to both stratify patients pre-operatively and evaluate their post-operative outcome [2, 20]. The authors suggested that men with a score of ≤ 6 were ideal candidates for augmentation, though the questionnaire was not validated. Ultimately, strict criteria do not exist, and patients should only be considered surgical candidates after thorough physical examination, psychological evaluation, and extensive counseling regarding the risks, benefits, and alternatives of the proposed intervention.

Similarly, there is no uniform measurement or reporting system for objective (i.e. penile size) and subjective (i.e. satisfaction) outcomes following penile augmentation procedures. For penile size measurement, not only are multiple methods available, but significant inter-observer variability exists [8, 21]. Furthermore, there are no established numeric thresholds for length or girth improvement that are considered universally indicative of a successful intervention. Likewise, no validated metrics for satisfaction

exist. The APPSSI is the only questionnaire specifically tailored to penile enhancement procedures, but it has never been validated beyond its initial description [2]. In the absence of validated metrics, many studies have measured subjective success using simple 1–5 scales of overall satisfaction or improvement, the value of which remains unknown. The lack of uniform outcome metrics and reporting necessitates careful, critical evaluation of all reports on penile enhancement therapies.

The terms “penile augmentation” and “penile enhancement” encompass many different techniques and approaches (Table 58.1). Enhancement procedures aim to improve either penile length or girth, but rarely both. However, girth- and length-enhancing procedures may be performed simultaneously to optimize overall size increase in both dimensions. There are two general categories of girth-enhancing procedures: injection

Table 58.1 Summary of non-surgical and surgical approaches to penile augmentation

Category	Technique
Girth augmentation (non-surgical)	Autologous fat injection
	Collagen injection
	Hyaluronic acid injection
	Silicone injection
	Poly-L-Lactic-Acid (PLLA) injection
	Polymethylmetacrylate (PMMA) injection
Girth augmentation (surgical)	Dermal fat graft
	Acellular dermal matrix allograft
	Acellular dermal matrix xenograft
	Silicone graft
	Tissue engineering
	Venous corporal graft
Length augmentation (non-surgical)	Rotational flap
	Traction therapy
Length augmentation (surgical)	Suspensory ligament division
	Skin flap with abdominal liposuction
	Slide technique
	Multiple-slit technique

therapy and surgical therapy with grafts, flaps, or implants. Lengthening therapies include penile traction, suspensory ligament division, skin flaps, and adjunct maneuvers at the time of penile prosthesis implantation. Here we review the techniques, outcomes, and complications of these approaches.

58.4 Girth Enhancement: Injection Therapy

Injection therapy entails the injection of autologous or foreign material into the subcutaneous penile tissues for the purpose of girth enhancement. These procedures have the appeal of a minimally invasive approach that is accompanied by a perception among patients and providers of decreased morbidity relative to conventional surgical approaches.

The ideal injectable material is highly compatible with native tissues, thereby provoking minimal adverse reactions. Sources for injectable fillers have ranged from autologous to synthetic with a range of biological materials that fall in between with regard to the extent of biocompatibility. While injectable materials can be classified by source and biochemical properties, other characteristics to consider include safety, ease of administration, cosmetic result, and expected permanence or need for additional procedures. The majority of research and experience with injectable compounds is derived from the plastic surgery and dermatology literature. However, many of these materials have been utilized for penile enhancement including autologous fat, collagen, hyaluronic acid, silicone, and others.

58.4.1 Autologous Fat

Autologous fat is considered an ideal substance insofar as it is highly biocompatible, readily available, and cheap. Fat tissue is collected via liposuction from the inner thighs or abdomen and then processed via centrifuge with removal of the oil fraction. The fat is then injected underneath the dartos muscle. Panfilov described a technique

for injection at four circumferential locations: 11, 1, 5, and 7 o'clock. At each location, approximately 10–16 mL of fat is injected, and care is taken to withdraw the injections with precision in order to ensure even fat distribution along the length of the shaft from the base of the penis to the coronal sulcus [18]. Adjunct massaging or kneading procedures can be performed to obtain better fat distribution.

Theoretically, autologous fat transfer is an uncomplicated procedure with low morbidity at both the donor and recipient sites. However, small series suggest that this may not be the case [22, 23]. Complications result from the traumatic nature of suction, transfer, and implantation of the adipose tissue. The cells are often ruptured or absorbed in the injection process or in the recovery period thereafter, leaving as little as 10% of adipose cells intact [24]. Uneven absorption and necrosis of transplanted cells can lead to asymmetry in the form of nodules, calcifications, granulomas, and curvature. Alternatively, if too much adipose tissue survives the transfer, the excess tissue may lead to patient complaints regarding erectile form and function [25]. There has even been report of a fat embolism after penile injection, a rare but lethal complication [26].

Few studies have examined outcomes following autologous fat injection. Kang et al. performed autologous fat injection in 52 men and reported mean girth improvement of 2.2 cm, though patient satisfaction was not assessed [27]. The authors reported just one complication in a single patient who developed a nodular fat pad. The nature of fatty tissue and its superficial injection location renders it easily accessible for removal or supplementation with subsequent procedures in the event that the cosmetic result is unsatisfactory. It is important to remember that the permanence of fat may have substantial variation, with reports of transplanted cell survival ranging from weeks to years [28].

58.4.2 Collagen

Collagen is a naturally occurring protein that underlies the structure of extracellular matrices

in human and mammalian connective tissues. Widely used in the field of plastic surgery for decades, collagen was considered a logical material for penile injection. Collagen can be sourced from a variety of animal models: human, bovine, and porcine. Bovine collagen derivatives require hypersensitivity testing, as up to 3% of patients receiving these collagens will develop a reaction [29]. Porcine products, due to their manufacturing process, do not require the same sensitivity testing [30].

While collagen has a high safety profile, it is rapidly degraded and has the shortest durability among all of the injectable materials. Despite its popularity and widespread use for cosmetic procedures, reports of its use for penile girth enhancement are scarce.

58.4.3 Hyaluronic Acid

Hyaluronic acid (HA) is the most commonly used soft tissue filler. Like collagen, HA is a naturally occurring material found in connective tissue. However, HA is a hydrophilic polysaccharide, whereas collagen is a protein. Because unmodified HA in its natural human form degrades rapidly, injectable HA is modified by crosslinking polysaccharide chains, thereby increasing its durability while maintaining biocompatibility [31]. HA is considered relatively safe for injection, and in the rare incidence of hypersensitivity or a poor cosmetic outcome, HA injection can be easily reversed with hyaluronidase.

Application techniques are similar to fat injection. HA is injected at four locations: 10, 2, 5, and 7 o'clock positions from the base of the penis to the coronal sulcus. In longer shafts, additional injection can be performed at the penopubic junction. Post-administration, the injected compounds can be manually molded in order to even the distribution of material throughout the penile shaft [32]. Kim et al. performed HA injection in 100 men and reported mean girth enhancement of 1.5 cm [33]. No adverse events were reported, and 77% of patients were satisfied with the outcome.

58.4.4 Silicone

Silicone is a synthetic, inert polymer that has been widely utilized by plastic surgeons. Due to its synthetic nature, silicone injection typically instigates a mild host inflammatory response. Neutrophils and monocytes infiltrate the target tissue resulting in a dense layering of collagen, giant cells, and fibrocytes surrounding the injected material [34]. This reaction serves to enhance the durability of the injection, an advantage over natural materials. However, injection of silicone is more technically difficult, and removal of the material in the event of complication or poor cosmesis can be challenging.

Severe complications after silicone injection are rare, but silicone migration along tissue planes to regional lymph nodes has been reported in non-penile usage [35]. Penile injection most commonly results in a local, self-limited inflammatory response but may also lead to granuloma formation, which can be disfiguring and distressing. While granulomas can be treated with topical and injected steroids elsewhere in the body, penile granulomas from silicone injection typically require surgical excision [34, 36].

Yacobi et al. reported the largest series of liquid silicone penile injection in 324 men. The authors performed injections of 5 mL on the dorsal and lateral aspects of the penis, repeated three to six times at intervals of at least 30 days [37]. On average, penile circumference improved by 2.6 cm (27% increase), and no post-operative complications were noted.

58.4.5 Additional Injectable Polymers

Polymethylmetacrylate (PMMA) is another permanent injectable polymer. Similar to silicone, PMMA induces a local inflammatory reaction that leads to collagen deposition [38]. PMMA is formulated in microspheres that can self-aggregate, thereby increasing the chance of asymmetric distribution within the target tissue. As such, commercial formulations are combined with bovine collagen to reduce the probability of

self-aggregation [39]. Like silicone, adverse events are rare but granulomas and bothersome nodules, when encountered, require surgical excision.

Other substances have been proposed for use in penile augmentation. Poly-L-Lactic-Acid (PLLA) is an injectable polymer used predominantly in facial plastic surgery. Like silicone, PLLA is notable for its bio-stimulatory properties but may require repeat sessions months or even years after the initial treatment [40, 41]. Calcium hydroxyapatite, the primary compound in bone and teeth, can also be injected to provide a scaffolding for bio-stimulation and collagen deposition [42].

Ultimately, despite the many available substances for penile injection, there is minimal evidence to support the use of any injectable material for penile girth enhancement. Outcomes are limited to a small number of retrospective, single-institution experiences. And while, theoretically, morbidity associated with these procedures is low, it is inappropriate to accept the risk of even a rare, severe complication without a clear potential benefit.

58.5 Girth Enhancement: Grafts, Implants, and Flaps

Many materials have been used for surgical penile girth enhancement in two principle approaches. The first entails circumferential, pericavernosal placement of the graft or implant in the potential space between the dartos muscle and Buck's fascia with the goal of increasing penile girth without enhancing the corporal bodies. This approach results in flaccid girth improvement, the so-called "locker-room appearance" of the phallus [43]. However, these procedures do not enhance corporal girth, and graft material may even be compressed in the erect state, thereby nullifying the girth-enhancing appearance. The second employs a corporoplasty technique through incision of the tunica albuginea and tunical graft placement with the goal of corporal enhancement for increasing functional girth of the erect phallus.

58.5.1 Dermal Fat Grafts

Autologous dermal fat grafts consist of dermis and subcutaneous tissues after removal of the epidermis. These grafts are used in plastic and reconstructive surgery in a variety of anatomical locations and clinical scenarios [44–46]. The precise mechanisms by which dermal fat grafts survive are unknown, but success likely depends upon atraumatic harvesting technique, sterile transfer, and early revascularization [7]. While more invasive than fat injection, dermal fat grafts offer the benefit of uniform, circumferential girth enhancement, which may be difficult to achieve with injections due to migration of injected material, formation of nodules, and inferior adipocyte survival with the injection technique [43].

For penile girth enhancement, dermal fat grafts are harvested from the abdomen, flank, or gluteal folds, following which the grafts are de-epithelialized resulting in free dermal fat grafts of approximately 0.5–1.5 cm thickness for circumferential placement overlying Buck's fascia (Fig. 58.2) [20, 43, 47].

Few authors have reported outcomes for dermal fat grafting in small cohorts. Spyropoulos et al. reported mean increase in penile circumference of 2.3 cm at the base and 2.6 cm at the coronal groove with dermal fat grafting [20]. More recently, Xu et al. performed dermal fat grafting in 23 patients who simultaneously underwent lengthening with suspensory ligament division. The authors utilized two, longitudinal dermal fat grafts, which were secured proximally to prevent graft migration [43]. At 6 months follow-up, mean flaccid girth increased by 1.7 ± 0.5 cm, and patient satisfaction was significantly improved in several domains of the Male Genital Image Score.

In addition to long operative time and donor site morbidity, the procedure may result in complications of penile edema, venous congestion, graft loss, penile hypoesthesia, and penile fibrosis resulting in curvature or asymmetry [7, 20, 43]. Xu et al. reported that the most common complication was self-limited post-operative prepuce edema (100%), followed by unnatural penile hair growth (21.8%), and hypertrophic scar formation (8.7%). The authors also noted

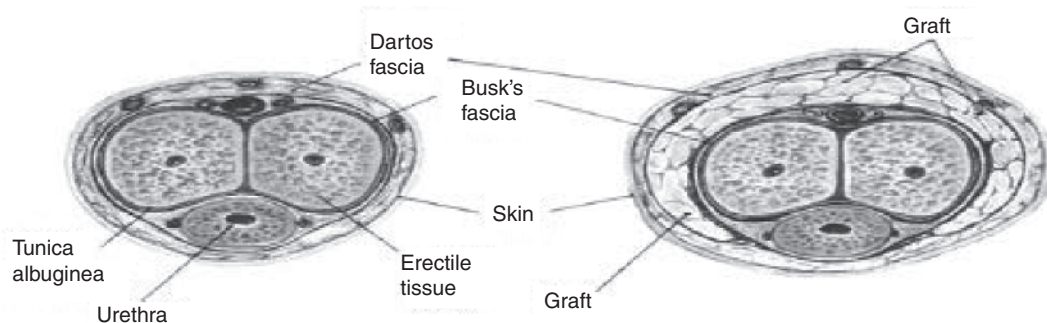


Fig. 58.2 Penile cross-sectional anatomy demonstrating optimal dermal fat graft placement between dartos and Buck's fascia

firmness of the palpable graft texture at 2 weeks post-operatively, however this resolved within 6 months with return of “natural soft and elastic texture” [43].

58.5.2 Allografts and Xenografts

In lieu of dermal fat grafts, some surgeons have utilized foreign graft materials for penile girth augmentation. These agents have the advantage of decreasing the morbidity and length of the operation, as tissue harvesting and processing is not required. Foreign grafts may also provide a more durable, uniform and desirable cosmetic appearance relative to fat grafts [7]. Conversely, these grafts are associated with complications such as infection, erosion, fibrosis, and vascular compromise of the penile skin leading to skin loss.

Allografts consist of acellular dermal matrix derived from human skin tissue [48]. These matrices are widely utilized in breast reconstruction, and there have been rare reports of use in penile augmentation [49]. Zhang et al. initially reported successful placement of acellular dermal matrix in 12 patients resulting in 2.6 cm mean increase in flaccid penile girth [50]. Bruno et al. subsequently reported the first two cases of complications following penile augmentation, which led to extensive penile skin necrosis requiring split thickness skin grafting in both [51]. Solomon et al. compared outcomes of girth enhancement with three different acellular

dermal matrix materials (AlloDerm®, Belladerm®, Repriza®) placed in a series of 47 patients [48]. Overall, 42% of patients had infectious complications, and 6.4% of cases resulted in total graft loss. There were no differences in complications among the different matrix preparations. It is important to note literature regarding the efficacy and cosmetic outcomes with allograft girth augmentation is lacking.

Xenografts used for penile augmentation are comprised of porcine acellular dermal matrix derivatives. Initial rat experiments demonstrated that these grafts promote neo-vascularization and collagen deposition with decreased inflammatory response relative to synthetic material [52]. Alei et al. reported the first series of penile girth augmentation with porcine dermal matrix grafts placed through a small penopubic incision. In a cohort of 69 men, mean increase in flaccid and erect circumference was 3.1 and 2.4 cm, respectively [53]. All patients experienced self-limited penile edema, and 8 patients had either massive ecchymosis or suture dehiscence. Additionally, graft fibrosis with reduced penile elasticity occurred in 8 patients. Nonetheless, the authors reported self-esteem improvement in 98% of patients according to the non-validated APPSSI [2]. Tealab et al. utilized Pelvicol®, a porcine xenograft, to perform girth augmentation in 18 patients [54]. Post-operative complications occurred in 8 (44.4%) patients, two of whom required graft removal. Despite improvement in penile girth, 9 (50%) patients were unsatisfied according to a non-validated questionnaire.

58.5.3 Tissue Engineered Grafts

Early investigations of tissue engineering for use in penile reconstruction suggested the use of bio-engineered cartilage rods for penile implantation [55, 56]. In 2006, Perovic et al. expanded upon this concept and published the first report of autologous tissue engineering with bioscaffolds for penile girth enhancement [57]. After tissue harvest via 1.0 cm skin biopsy under local anesthesia, dermal tissue was processed and incubated with a biodegradable polylacti-co-glycolic acid (PLGA) scaffold for approximately 24 hours. The autologous tissue was then surgically implanted between the dartos and Buck's fascia using a circumferential, subcoronal incision.

The authors reported results from a series of 84 patients who underwent girth enhancement with engineered autologous tissue. At mean follow-up of 24.7 months, mean flaccid and erectile girth increase was 3.15 ± 0.42 and 2.47 ± 0.49 cm, respectively [57]. Post-operative complications included skin necrosis in two patients, seroma in six patients, and wound infection in two patients, all of whom were managed conservatively. Using a non-validated questionnaire, the majority of patients reported complete satisfaction following the procedure. In a subsequent study, the same authors expanded upon this technique using dartos fascia in lieu of dermis [58]. Histomorphometry and immunohistochemistry performed on biopsies of the engineered tissue revealed de novo synthesis and accumulation of mechanically stable dartos tissue. While these early studies show promise for tissue engineering in penile enhancement surgery, these techniques should be considered experimental until additional well-designed trials demonstrate safety and efficacy.

58.5.4 Silicone Implant

The silicone sleeve implant (Penuma®) is the only Food and Drug Administration (FDA)-approved synthetic device for use in penile girth enhancement. Elist et al. reported a series of 400 patients who underwent silicone implantation

with mean penile girth increase of 56.7%. The most common post-operative complications were seroma (4.8%), scar formation (4.5%), and infection (3.3%) for which 3% of patients required implant removal. At mean follow-up of 4 years, 81% of patients reported "high" or "very high" satisfaction using the APPSSI [59]. Additional studies are required to further evaluate the efficacy of the device.

58.5.5 Venous Grafts

Due to the inability of circumferential grafting procedures to enhance erectile girth, Austoni et al. developed a corporoplasty grafting procedure for erectile girth enhancement [60]. After degloving the penis through a combination of circumferential subcoronal and median penoscrotal incisions, bilateral longitudinal incisions are made in the corpora extending from the corporal base to the apex at the glans penis, thereby achieving the corporal expansion. The saphenous vein was then harvested and used as a graft for corporal closure, thereby preserving the girth expansion. In a series of 39 patients, the authors reported mean erectile girth increase of 1.4 cm. No major post-operative complications were encountered, and there was no change in sexual function post-operatively as measured by nocturnal penile tumescence.

Yang et al. utilized the same corporoplasty technique, comparing venous and artificial polytetrafluoroethylene (ePTFE) grafts in 20 men with either congenital micropenis or penile dysmorphism [61]. The authors reported increase in erectile girth ranging from 1.5 to 3.0 cm. All patients had self-limited penile edema in the immediate post-operative period, but no major complications ensued. Measures of patient satisfaction and erectile function were not reported.

58.5.6 Flaps

Rotational flaps are more reliable than grafts insofar as they maintain their original blood supply. This minimizes complications typically

associated with poor graft take such as skin necrosis, fibrosis, and asymmetry. Shaeer et al. reported the first case of a penile fasciocutaneous flap for girth augmentation. In a 27 year old man with complaints regarding his penile girth, the authors performed a groin flap consisting of skin from the lateral groin and extending from the femoral vessels to the posterior iliac spine [62]. The flap was based on the arterial supply from the superficial circumflex iliac artery with an arc of rotation over the femoral vessels and beneath the inguinal ligament. Shaeer et al. subsequently published results from flap augmentation phalloplasty in a series of 40 patients [63]. At a minimum follow-up of 18 months, patients had mean girth improvement of 5.2 cm (55.6%).

58.6 Penile Lengthening Procedures

58.6.1 Penile Traction Therapy

As noted above, penile traction therapy has deep historical roots and has been used in varying forms for thousands of years. The physiologic basis for penile traction therapy stems from the principles of tissue remodeling that are employed by orthopedic and plastic surgeons in the use of tissue expanders. In vitro, tissue stretch results in fibroblast remodeling and collagen rearrangement, which is among the proposed mechanisms for the efficacy of traction therapy [64, 65].

Traction therapy has typically taken two forms, application of penile-extender devices or vacuum erection devices (VEDs). The penile-extender devices such as the FDA-approved Andro-Penis® consist of an apparatus surrounding the penis that facilitates a regimen of gradually increasing traction over time. The device includes a plastic ring, through which the penis is introduced, attached to two dynamic metallic traction rods. An additional silicone component stabilizes the glans, and the patient is instructed to gradually increase the traction over time according to a specified regimen [66].

Gontero et al. performed a prospective, pilot study of the safety and efficacy of the penile-

extender device for management of men with self-described “small penis” [66]. Twenty-one men were instructed to use the penile-extender device for at least 4 hours daily during a 6 month period. Initial penile traction force of 600 g was applied for the first month, and this was increased slowly to a maximum of 1200 g during the fifth and sixth months. At 6 months, mean flaccid and stretched penile length increased by 2.3 and 1.7 cm, respectively. This was accompanied by an overall mean satisfaction of 2.8 on a 0–4 scale. Only two minor complications were noted, one case of penile bruising and one case of penile discoloration. The authors concluded that penile-extender therapy is a safe, minimally-invasive therapy with mild efficacy.

Norwoozi et al. performed a larger, follow-up study of the same penile-extender device in 54 men [67]. At 6 months follow-up, they found increase in mean flaccid, stretched, and erect penile length of 1.7 ± 0.8 , 1.3 ± 0.4 , and 1.2 ± 0.4 cm, respectively.

The VED has been approved for treatment of erectile dysfunction in the United States since 1982, but it has also been used off-label for penile traction therapy [68]. Many versions are commercially available, but all share the essential three components of a penile cylinder, a vacuum pump (battery or hand-operated), and a penile constriction ring [69]. The patient inserts his penis through the constriction ring and then applies the cylinder, using the pump to generate negative pressure up to 225 mmHg, which results in erection via passive inflow of mixed venous and arterial blood.

Kohler et al. examined the efficacy of VED for preservation of penile length after radical prostatectomy [70]. In a randomized trial of early VED use (1 month post-prostatectomy) versus control (6 months), stretched penile length was preserved in men with early whereas 2.0 cm loss of stretched penile length was observed in the control group. In contrast, there was no loss of flaccid penile length in either group during the study period. Similarly, Dalkin et al. found that stretched penile length was preserved in 97% of men who adhered to the prescribed VED regimen post-prostatectomy [71].

To date, there are no studies examining the use of VED for penile augmentation.

The few available studies suggest that penile traction therapy has minimal morbidity and may have mild efficacy for penile lengthening. While both penile-extender devices and VEDs have been shown to be efficacious in the treatment of Peyronie's disease, there is a paucity of data and lack of randomized trials demonstrating the efficacy of these techniques for penile augmentation [17]. As such, we do not recommend the routine use of penile traction therapy for penile lengthening.

58.6.2 Suspensory Ligament Division

The suspensory ligament of the penis is a fibrous structure attaching the tunica albuginea of the penile base to the pubic symphysis, which stabilizes the mobile portion of the penis during erection (Fig. 58.3) [72]. Dissection or division of the suspensory ligament enables forward advancement of the corporal bodies such that the flaccid penis is more protuberant and appears closer to

its erect length [7]. Using a general anesthetic approach, a transverse or inverted-V suprapubic incision is utilized to expose the penis and suspensory ligament [7, 18]. With the penis on stretch, the ligament and its surrounding attachments to the periosteum of the pubic bone are divided [73]. In order to prevent reattachment of the penis to the pubic bone or even penile scarring and shortening during healing, multiple authors have suggested filling the intervening space between the penis and pubis with either autologous or implant material. Alter et al. utilized a vascularized spermatic cord flap, which was sutured to the pubic periosteum, whereas Li et al. utilized a silicone buffer (i.e. a testicular prosthesis) as a filler [47, 73]. Post-operative care typically consists of penile traction therapy to further prevent reformation of penile attachments and scarring that may lead to shortening.

Objective success following suspensory ligament division is difficult to quantify, as change in penile length is reported in very few series and measurement techniques vary. Li et al. performed suspensory ligament division in 27 patients and found mean length increase of 1.3 ± 0.9 cm [73]. Spyropoulos et al. performed suspensory ligament dissection in 11 men using a variety of techniques and found mean flaccid penile length increase of 1.6 ± 0.4 [20]. Panfilov performed suspensory ligament dissection in a subset of 28 patients who simultaneously underwent autologous fat transfer and reported a mean length increase of 2.4 cm [18]. Similarly, Monreal performed suspensory ligament release in 148 patients who underwent concurrent autologous fat transfer and found mean length increase of 3.1 cm at 12 months follow-up [74].

Patient satisfaction after suspensory ligament division is variable among reported series and does not appear to correlate with objective penile length increase. Despite the reported 1.3 cm mean length increase, Li et al. found that just 27% of patients were satisfied with the procedural outcome [73]. Likewise, Klein et al. found that 69% of men did not achieve the expected penile length, and 62% were unhappy due to post-operative changes in erectile function [7]. In contrast, Spyropoulos reported significant

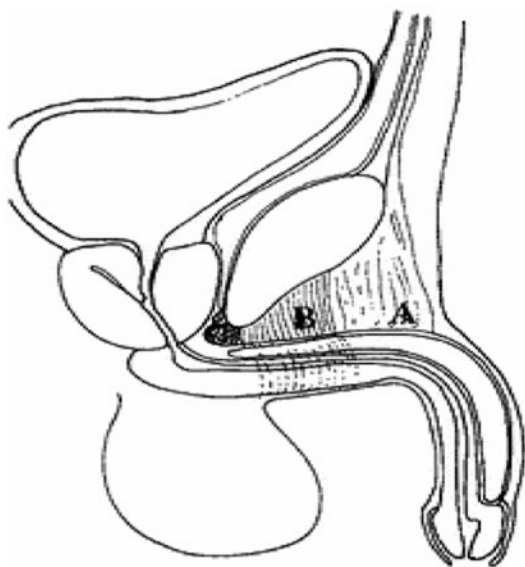


Fig. 58.3 Sagittal view of the peno-pubic anatomy and suspensory ligament apparatus indicating (a) the fundiform ligament, (b) suspensory ligament, and (c) arcuate subpubic ligament

improvement in sexual self-esteem and function in 91% of patients who underwent a variety of augmentation phalloplasty procedures [2, 20].

Complications after suspensory ligament division include infection, sexual dysfunction, penile shortening, and poor cosmesis. Klein et al. reported 45% post-operative infection rate, and both Li and Roos reported 5 and 4 cases of serious post-operative infection, respectively [7, 73, 75]. Klein et al. also noted that the majority of patients (60.3%) had changes in erectile function with regards to pain, curvature, and angle of erection.

Wessells et al. examined 12 patients presenting to a single referral center after penile enhancement surgery elsewhere. All 12 patients had suspensory ligament release, and the majority had concurrent autologous fat injection. Wound complications occurred in 50% of patients, and the majority of men were unhappy with the cosmetic result [76]. Sexual dysfunction was reported in one third of patients, and half of the patients ultimately required operative revision. Only one of 12 patients reported subjective length following the procedure.

Given these findings and the general paucity of evidence, the American Urological Association (AUA) issued a policy statement noting that, “the AUA also considers the division of the suspensory ligament of the penis for increasing penile length in adults to be a procedure which has not been shown to be safe or efficacious” [77]. While division of the suspensory ligament is technically feasible, we do not recommend its routine use for penile enhancement.

58.6.3 Penile Skin Flap and Abdominal Liposuction

In certain men, full extension of the erect penis may be limited by the penopubic skin, suprapubic fat pad, penoscrotal webbing, or iatrogenic penile skin shortage following circumcision. For these cases, and during concurrent penile elongation procedures, local skin flaps can be performed in order to advance the penopubic or penoscrotal skin onto the penis.

The original and most commonly employed flap is the V-Y advancement flap. Initially described by Long et al. in 1990, it was modified and popularized by Roos and Lisssoos in 1994 for use in conjunction with suspensory ligament release [75]. The original technique utilized an inverted V incision made just proximal to the penopubic junction with subsequent mobilization of the skin and subcutaneous fat tissue to perform the Y-plasty. Others have employed the technique for penile shortening secondary to penoscrotal webbing [78]. Due to the fact that these flaps are distally based, complications may include penile scrotalization, penile edema, poor wound healing, dehiscence, and even distal flap loss [7]. Additionally, the skin of the advanced flap differs from normal penile skin insofar as it is thicker and hair-bearing, both of which may impair the cosmetic result [79].

Due to these limitations, other flap techniques have been employed. Horton et al. described the use of a classic Z-plasty for suprapubic lipectomy in men with a buried penis [80, 81]. This technique utilizes a Z-plasty incision at the penopubic angle, which avoids the potential for scrotalization of the penis, but still requires advancement of hair-bearing skin onto the penis. Other flaps such as a double Z-plasty, W reconstruction, and others have been used [79, 82].

In addition to skin flaps, adjunct maneuvers have been specifically described for management of buried penis. Maizels et al. initially described an abdominal approach in the pediatric population with removal of hypogastric fat deposits and tacking sutures from the basis of the penis to the pubic periosteum [83]. Alter et al. adapted this approach for the adult population, placing tacking sutures from the subdermis of the ventral penoscrotal junction to the tunica albuginea in 6 adult patients [79]. In some patients, additional tacking sutures were placed from the penopubic subdermis to the rectus sheath. More recently, others have used simple suprapubic liposuction for management of acquired buried penis, which offers decreased morbidity but equivocal results [84].

It is important to note that these procedures do not increase corporal length, but merely manipu-

late the skin and subcutaneous tissues to provide the appearance of a larger phallus. Furthermore, the reports of these techniques have been limited to single-surgeon, single-institution series with minimal reporting of outcomes and complications. While flap procedures may be appropriate on an individual patient basis, we do not recommend the routine use of these procedures.

58.6.4 Penile Lengthening Procedures for Prosthesis Implantation

In addition to the aforementioned stand-alone lengthening techniques, a number of new techniques have been described for penile lengthening at the time of penile prosthesis insertion. Prior evidence has shown that penile prosthesis insertion may be associated with loss of penile length, which has served as the impetus for the development of adjunct maneuvers to preserve or increase penile length at the time of insertion [85].

In 2012, Rolle et al. described the “sliding” technique for penile lengthening in the management of men with Peyronie’s disease and erectile dysfunction. Tunical releasing incisions were made prior to prosthesis insertion and subsequently repaired with dorsal-ventral patch grafts using porcine intestinal mucosa [86]. Egydio et al. modified this technique to exclude the use of a graft [87]. In a cohort of 143 men who underwent the modified “sliding” technique, mean penile length increase was 3.1 cm. While minor complications were not reported, there was no incidence of prosthesis infection or explantation at 6 months follow-up.

The multiple-slit technique (MUST), an evolution of the prior maneuvers, appears similarly effective for increasing penile length at the time of prosthesis insertion [88]. Egydio et al. reported mean penile length gain of 3.1 cm (range 2–5 cm) in 138 men who underwent MUST with either an inflatable or malleable prosthesis insertion. One patient developed glans necrosis, but no patients developed infection or required device explant.

Initial results from these single-institution series are encouraging. However, additional studies and randomized trials are required to demonstrate safety and efficacy before these adjunct maneuvers can be recommended for routine use at the time of prosthesis insertion.

58.7 Conclusions

Many techniques have been employed in the name of penile augmentation. Ranging from the minimally-invasive such as penile traction and injectables to the surgical approaches such as suspensory ligament division, select small case series offer encouraging results. However, the quality of evidence for all of these therapies is lacking. Very few randomized trials have been conducted, and there are no universal standards for reporting of outcomes and complications. In aggregate, patient satisfaction is equivocal following these procedures, a crucial outcome when considering an elective intervention aimed to increase quality of life [89].

Until high-quality studies are performed, all approaches to penile augmentation should be considered experimental, a sentiment that is reflected in the professional society guidelines. The AUA issued a policy statement noting that, “the AUA and the Urology Care Foundation consider subcutaneous fat injection for increasing penile girth...and division of the suspensory ligament of the penis for increasing penile length in adults to be a procedure which has not been shown to be safe or efficacious” [77]. Likewise, the International Society for Sexual Medicine recommends that, excepting men with a microphallus, “penile length augmentation surgeries are not recommended for men with a normal penile size (7.5 cm or above), as they have neither been proven effective nor safe” [90]. We agree that at present time, penile augmentation should be considered experimental, and patients should undergo these therapies only within the context of institutionally-approved protocols. We look forward to future research in this area.

Key Summary Points

- Human civilization has been preoccupied with penile augmentation from time immemorial
- Microphallus, penile trauma, and dysmorphism are appropriate indications for penile enhancement
- Thorough physical and psychological examination along with counseling must be performed prior to any intervention
- Numerous injectable materials, grafts, and implants have been utilized for girth enhancement
- Penile traction, suspensory ligament division, localized skin flaps, and liposuction have been utilized for length enhancement
- Penile prosthesis placement can be an opportunity for additional surgical maneuvers to increase penile length at the time of implantation
- Evidence of safety and efficacy is lacking for all of the aforementioned approaches
- Additional research is needed to examine complications, efficacy, and patient satisfaction before penile augmentation can be considered anything other than experimental

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Penile Self-Injections for Girth Augmentation: Treatment of Complications

59

Boyke Soebhali

59.1 Introduction

Augmentation of penile girth has always been a subject of extensive debate and controversy [1]. Foreign materials such as mineral oils, paraffin oils, paraffin balm and silicone have been used in order to improve penile shaft contour and dimensions [2]. Warmed Vaseline is also known as injected material in Europe [3]. Genital injection of high-viscosity fluids like paraffin and mineral oil has been performed for more than 100 years [4]. The liquid is injected subcutaneously, in the hope that it will add the girth diameter of the penis [5]. Injection often performed by non-professional persons or by the patients themselves, in a non-standardized way [6]. Only after sometime, the destructive consequence of the injection occurred.

A chronic sclerosing inflammation often leads to disastrous functional impairment (Fig. 59.1). Nodules, skin ulcers, necrosis, blindness, and death have been known as the side effect [6–8]. Cellulitis or transmission of diseases such as HCV, HBC and syphilis can also lead to complications [5]. Inability to perform sexual activities, penile deformity, acquired phimosis, painful intercourse that can lead to emotional distress are common among patients with complications [3, 9].

The abnormality can be named according to the injected materials (vaselinoma, siliconoma, paraffinoma) or it can be called sclerosing lipogranuloma, a name introduced by Smetana and Bernhard in 1950, or Liponecrosis (Table 59.1) [10, 11]. Actually, sclerosing lipogranuloma does not always develop following the injections. Different reactions can be related to varying degrees of purity of the injected material. But apparently, the determining factor of sclerosing lipogranuloma formation is the sensitivity of the patient's tissue [12]. This practice of penile injection is still continued in some countries in Asia, especially South East Asia, Korea and Middle East, and some Eastern European countries [6, 13, 14]. In Eastern Europe, most of affected patients have risky social behaviour such as prisoner and beggar [15]. In the author's experience, in Indonesia many of the affected persons were soldiers, sailors or coal miners.

59.2 Historical Perspective

Since antiquity, the presence of a large male sexual organ has been regarded as a symbol of strength, especially with regard to physical fitness and sexuality [2, 3, 13]. For a long time, the size of the phallus and scrotum has been a source of worry to men. It has various psychological and social ramifications, such as lack of self-confidence, fear of relationship, and social

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Fig. 59.1 Common appearance of sclerosing lipogranuloma of the penis. (From author's personal archive)

Table 59.1 Various names of sclerosing inflammation after penile injection [1, 3, 5, 7, 10, 11, 14]

Penile paraffinoma
Penile siliconoma
Penile vaselinoma
Penile Oleogranuloma
Sclerosing lipogranuloma of the penis
Mineral oil granuloma of the penis
Penile foreign body granuloma
Liponecrosis of the penis

maladjustment [16]. Discussion of the penis often deemed taboo, socially unacceptable. In other times, it was the topic of light-hearted conversation and jokes [17].

In some primitive tribes, foreign body injection to augment the penile contour was a part of cultural activity [18]. The implantation of foreign material to make the girth of the penis bigger has been described since Kama Sutra [19]. The Topinama of Brazil, has a tradition of having poisonous snake to bite their penis to make it bigger. In the Dayak Borneo tribe, a ritual of piercing the glans and insertion of items into the resultant holes was widely practiced in the past [20].

In modern record, the use of mineral oil for genital augmentation was first performed by Robert Gersuny (an Austrian surgeon from Vienna) when he injected Vaseline to a boy who had undergone bilateral orchiectomy because of genital tuberculosis [6, 13, 21, 22]. The success of the procedure encouraged him to use Vaseline

as filling material for other soft tissue defect. Different body organs (e.g., the penis, breast, cheek, eyelids, muscles and nose) were injected with foreign materials [14]. Successful results were reported. Later, paraffin injection was also used to treat urinary incontinence [15]. Different types of injected material are presented in Table 59.2.

Complications of this type of procedure were reported as early as 1906 by Heidingsfield. Two patients underwent mineral oil injection for facial wrinkles. As the results, they developed bad nodules on the face [21–23]. Because of the complications, this practice was subsequently abandoned in many countries [6]. It is true that some patients had no complication, but most of the time the injected materials cannot be metabolized. Human body lacks the enzyme to break down exogenous lipid. Thus a foreign body reaction occurs [6, 23]. Life-threatening adverse reactions were also reported, including pneumonitis and embolism. This is due to inadvertently intravascular administration of the mineral oil [15]. Delayed sequelae presentation may include foreign body granulomas, and increased risk of penile cancer [15].

The practice of injecting mineral oil to the genital area is almost always illegal. Penis enlargement is the most common reason to perform this procedure [6]. The persons injected are somewhat ashamed for having to use injected materials to attain an enlargement, so severe complications can often remain hidden [3].

In Indonesia, there are so called “traditional health practitioner” that claimed to have the ability to enlarge the penis using massage, natural oil and spiritual power. Some of them will show bamboo shafts with different diameter and ask the patient to choose the penis size they expect according to the bamboo size. The ritual for penile enlargement includes massage of the body (including the penis), mostly with the patient's eyes closed. After the massage, the traditional health practitioner will perform “acupuncture” to the penis, then continue the massage. Most likely the “acupuncture” is injection of mineral oil, and the massage was performed to help divert the pain and to distribute the injected mineral oil evenly. The author's clinic receives

Table 59.2 Injected materials [15, 18, 24, 25]

Medical substances
Autologous fat
Polyacrylamide
Fluid silicone (polydimethylsiloxane)
Collagen
Hyaluronic acid
Non-medical substances
Mineral oil (incl. Coconut oil, palm oil, olive oil)
Vaseline (liquified by warming)
Liquid paraffin
Metallic mercury
Petroleum jelly
Transmission fluid

Note: most of the patient in author's hospital cannot name the oil injected

many patients with sclerosing lipogranuloma of the penis after treatment from such traditional health practitioners (Table 59.2).

59.3 Clinical Presentation

Clinical presentation of sclerosing lipogranuloma of the penis varies depending on the amount of injected material, composition, site of injection, depth and duration since the injection [6]. After injection of the mineral oil, in many patients the symptoms will occur almost immediately. Swelling, inflammation of the penile skin, redness, oedema (that will give an impression of larger penile girth) are among the symptoms occurred. There will be painless mass at first, in many patients it will stay that way for years. The lesion has lag time from weeks to years before disastrous symptoms come. The lag time can be from two days up to 30 years [26, 27]. The long period between injection and the adverse sequelae will make it difficult to make a proper diagnosis. A urologist must always keep this in mind when developing a differential diagnosis of irregular mass of the penis, because many patients deny having mineral oil injection at first [28, 29]. Since many patient will try to conceal or deny any injections to the genital, a thorough analysis of the lipid after removal is mandatory to at least demonstrate its exogenous origin [30].

The liquid injected materials and the tendency of the patient to massage the injected parts enable the injected materials to migrate over other areas of the external genital, including regional lymph nodes that can cause clinical confusion with a neoplasia [29]. The migration is due to the large-volume, low-viscosity materials which do not allow encapsulation of the injected material [25]. Acquired phimosis can develop on uncircumcised patients, as the prepuce can act as a storage for the injected materials [14]. The injected materials can also fill the suprapubic area and the scrotum. When the injected material fills the scrotum, it will make the same clinical appearance like the one in the penis. Migration of the mineral oil to the scrotum will make reconstruction of the deformity more difficult, because the scrotum is a very good source for skin to close the defect after excision of the scarred area.

After some time, in some patients the painless mass will become fibrous, harder, painful, or ulcerative (Fig. 59.2). Sometimes the patients call it 'woody penis' [19]. The skin becomes sensitive at the injection site, often with pigmentation or dark, yellowish discoloration [5]. Prolonged inflammatory reaction may result in abscess formation, lymphangitis and inguinal lymph nodes enlargement [27]. The inguinal lymph involvement can even mimic incarcerated



Fig. 59.2 Inflammation and ulceration after mineral oil injection. Notice the suprapubic fat involvement, but the scrotum is relatively free of defect. (From author's personal archive)

inguinal hernia [23]. Deformed penis is usually observed because of the hardened skin [2]. Pain in erection is also reported, because the hard skin of the penis will limit the penile erection [29]. Usually the glans and cavernous body are not involved, but sometimes the sulcus coronarius is affected [27]. Complaints also included difficult intercourse and coital pain for both the patient and the female partner [1, 2].

Most of the patients who underwent mineral oil injection to the penis are unsatisfied with the result [15]. They performed the injection in hope to facilitate erection or increase the sexual potency, unfortunately there was no improvement in their sexual life. Even in the no-complication cases, the patients complained about discomfort and decreased sexual potency [31].

59.4 Histology

Histology findings usually showed marked thickening of reticular dermis with aggregates of vacuoles in varying size, surrounded by chronic inflammatory changes [26, 28]. In the acute phase, acute inflammatory cells, neutrophil granulocytes can be observed in and around the vacuoles, along with abscesses and phlegmonous appearance [10].

59.5 Treatment Options

The main purpose of treatment is to restore penis function as a sexual organ with acceptable cosmetic appearance [2]. Many options have been offered as the treatment of sclerosing lipogranuloma of the penis. The treatments are very dependent on severity and complexity of the case, also the skill and experience of the surgeon. A conservative approach using antibiotics is proposed to reduce the fever and swelling [14]. This approach will not cure the disease, and only suitable for very selected cases, mostly for patients with communication difficulties or fear of surgery [32]. Intralesional steroid injection is also proposed, but there is no published data of intralesional steroid injections to treat

penile sclerosing lipogranuloma [7]. No spontaneous regression of paraffinoma has been reported [21].

So far, surgery is the best viable option to treat this disease [2, 30, 33]. The surgical treatment is deemed complex reconstructive procedures, time consuming and sometimes requires staged procedures [9, 15]. For definitive treatment, complete excision is necessary to remove all the granuloma and involved regional lymph node [30]. Usually a plane between the hardened inflamed tissue and the corporal body exists [9]. This plane makes the separation of the inflamed tissue from the penis possible. If complete excision cannot be achieved, recurrence of the symptoms will most likely occur [14]. Every attempt to excise the granulose nodules alone subcutaneously to preserve the skin in many cases will end with even worse scars or skin necrosis [29] (Fig. 59.3). In some cases that involve the sulcus coronarius, the corona has to be excised too, otherwise the patient will complain of “hard band” around the shaft penis after surgery because the hard tissue leftover.

In our centre, we prefer to perform surgery at least six months after injection. Inflammation and induration make it very difficult to find the demarcation of the granulomatous tissue, and infection can lead to flap/graft procedure failure. Early after injection, a lot of tissue look reddish and oedematous. We prefer to give antibiotics and Nonsteroidal



Fig. 59.3 Scarring after removal attempt of subcutaneous lipogranuloma while preserving the defected skin. (From author's personal archive)

Anti-inflammatory Drugs (NSAID) and wait until the inflammation resolved. After six months, the good tissue will be easier identified.

The surgical options after complete excision vary, depend of the location and size of the defect. Small and isolated lesion (up to one third of the penis) most of the time can be treated with primary closure or circumcision (Fig. 59.4). Wider defect must be closed with skin from other location. Split Thickness Skin Graft (STSG), Full Thickness Skin Graft (FTG) (Fig. 59.5), scrotal flap and Cecil's scrotal implantation are some of the choices of procedures for this disorder [31]. Most of the procedures are complex plastic reconstructive surgery, which mostly require a special training/fellowship. For non-reconstructive surgeon/urologist, Cecil's two stage scrotal flap is a good choice because it is a relatively simple procedure. The two-stage procedure consists of: [1] complete excision of the granuloma and covering of the denuded penis shaft with available scrotal skin, and [2] V-Y incision of the scrotum after 3–6 months to reconstruct the penis. This technique can still be performed even if half of the penile skin is involved. For a properly trained surgeon/urologist, a simple tips and tricks will help perform this procedure (Figs. 59.6 and 59.7).

Although a relatively simple procedure, there are some things that one must always keep in mind, in order to achieve good surgery outcome of the technique. The main principle is to remove all the lipogranuloma. Small pieces of granuloma will be enough for the patient to claim failure, also will make new granulomas. Sometimes the corona is involved. In this case, the corona must also be excised to prevent “hard-band” around the glans after surgery. We always use drain in the procedure. In the first stage we will use up to two vacuum drains. One vacuum drain is placed in scrotum, other drain is in the suprapubic space if the lipogranuloma extends to the suprapubic area.



Fig. 59.5 Full thickness skin graft [34]. (From Park and Shim, used by permission)



Fig. 59.4 Simple incision and primary closure for minimal lesion. (From author's personal archive)

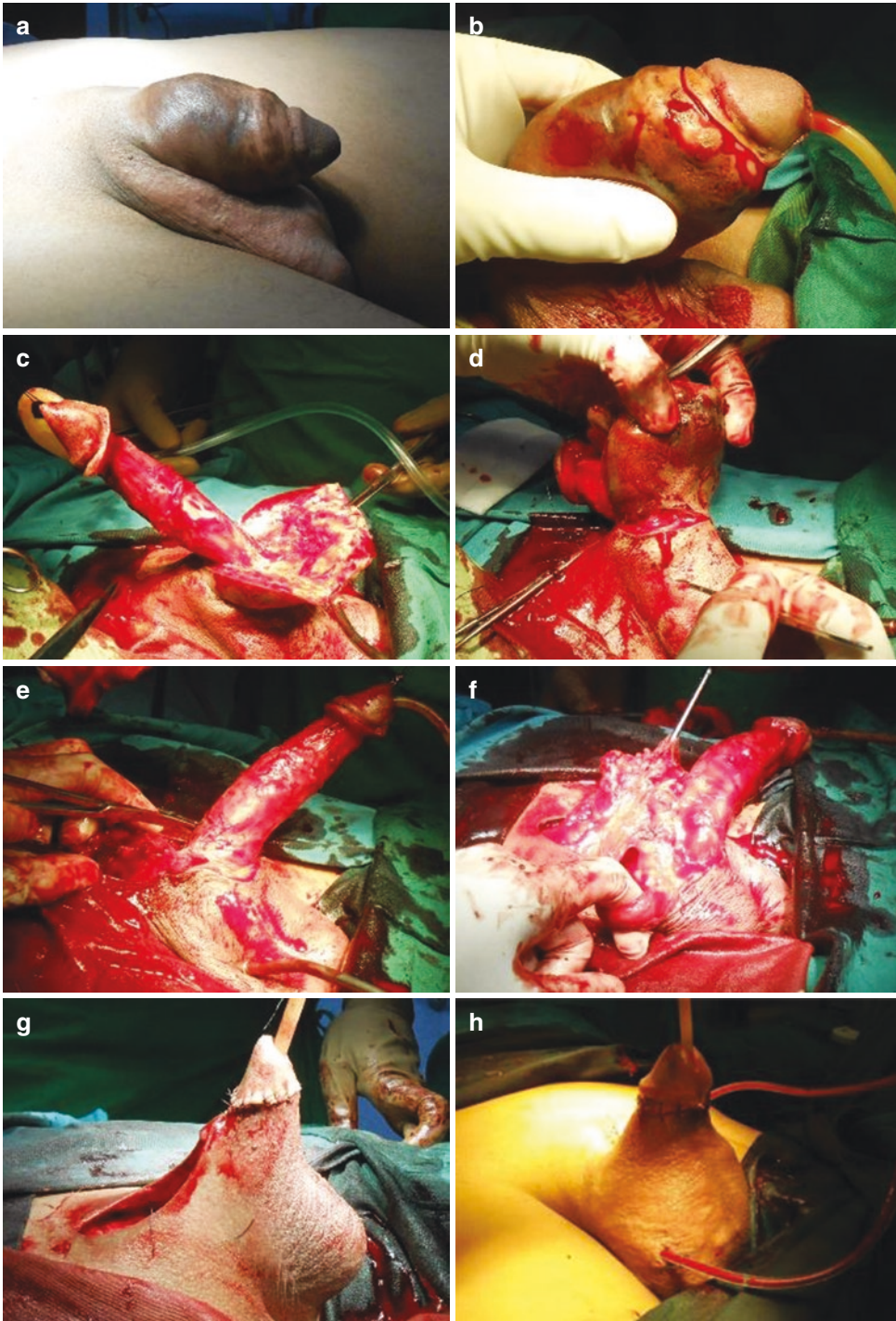


Fig. 59.6 The first stage of Cecil's scrotal flap. The sclerosing fibromatosis in (a) looks simple. A circular incision was made, followed by a longitudinal incision up to the suprapubic area (b) then the penis was degloved (c). Notice in this picture, the hardened corona is still in place. In (d) the granulomatous part was excised. (e) showed the denuded penis,

with the corona still intact. Further exploration in (f) showed the lipogranuloma at the suprapubic area being excised, and the granulomatous corona was cut. (g) showed the corona had been excised, and the scrotal skin was covering the penis. Drain after surgery is very important (h) to prevent hematoma. (From author's personal archive)

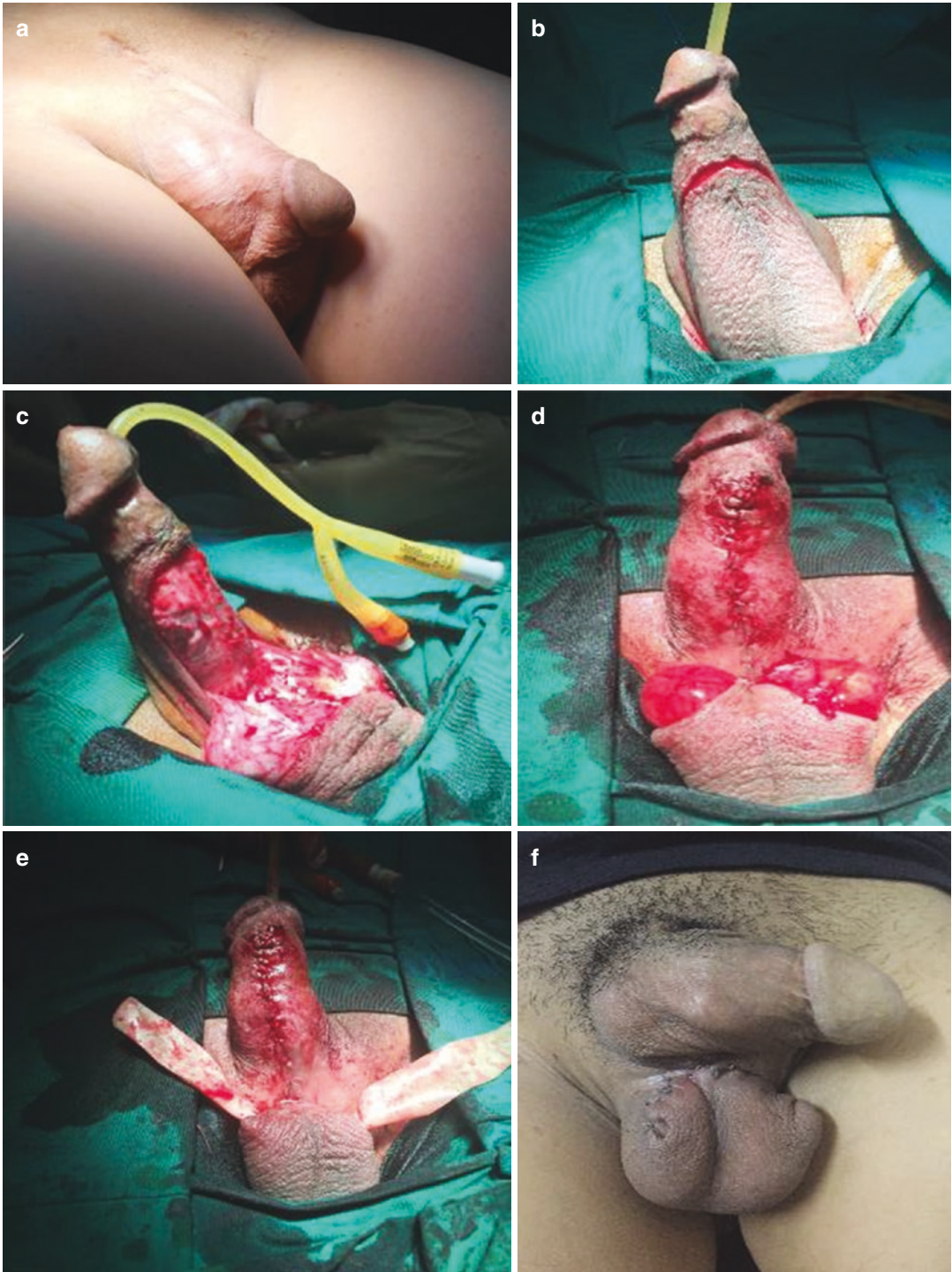


Fig. 59.7 The second stage of Cecil's scrotal flap procedure. In (a) we can see the appearance of the scrotal-skin-covered penis six months after the first procedure. An inverted-U (or inverted V) incision was made on the ventral side (b). The penis then released from the scrotal skin

(c). Thereafter, an inverted Y suture was made (d) and a Penrose drain was placed in the scrotum to prevent hematoma (e). In (f) we can see the appearance of the penis four weeks after surgery. (From author's personal archive)

In our early experience, without drains some patient might develop hematoma after surgery. Later the hematoma required other surgery to fix. In the second stage, we place a Penrose drain in the scrotum. We usually put Foley catheter and compression dressing for 3–4 days, and the drains will be taken out along with the compression dressing.

The Cecil's two stage scrotal flap has some advantages. It is a relatively easy procedure to perform, with no special training needed for surgeons/urologists. The dartos layer in the scrotal skin will make the penis "slide", giving a "real penis skin" feel. Unlike the skin grafts, which will stick to the corporal body, the scrotal skin can be moved and "pinched" after being placed on the penis. The results are very good. In the author's hospital in Samarinda, Indonesia, from May 2008 to December 2017 we have performed surgery on 356 cases of sclerosing lipogranuloma of the penis. From those cases, 21% of the patients refused to undergo the second procedure, because they were satisfied with the first stage surgery.

Beside the advantages, Cecil's two stages scrotal flap also has its disadvantages. The main disadvantage is actually the two stages, which means two surgeries, thus has psychological and economical disadvantages because the time spent to wait for the second surgery [31]. Hairy penis is also a 'relative' disadvantage (Fig. 59.8). We call it 'relative' because in our experience the patients

usually refuse to get treatment for the hairy penis. They refuse further treatment because to most of them, hairy penis is something 'fancy' for them and the sexual partner. Some patients also complain about the shortening of the penis, but this complain usually can be treated by performing a simple V-Y plasty to elongate the penis.

Other scrotal flap techniques are basically based on the two-stage scrotal flap reconstruction. Park and Shin offer a one stage version of the Cecil's two stage procedure (Fig. 59.9).

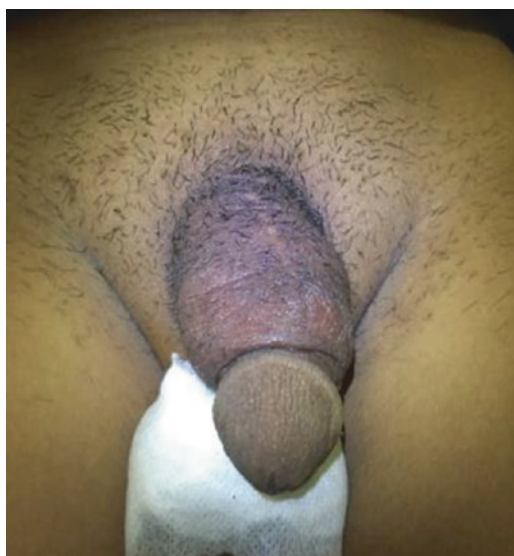


Fig. 59.8 Hairy penis after second stage surgery

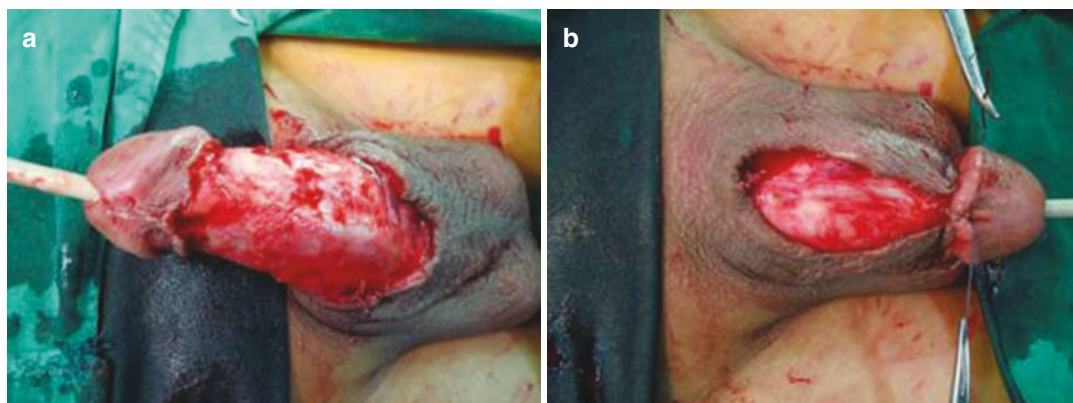


Fig. 59.9 One stage bilateral scrotal flap. Complete removal of the granuloma (a) followed by bilateral scrotal flap (b and c). A V incision will be performed in the ven-

tral aspect (d and e). Closure of the ventral wound (f) [34]. (From Park and Shin, Used by permission)

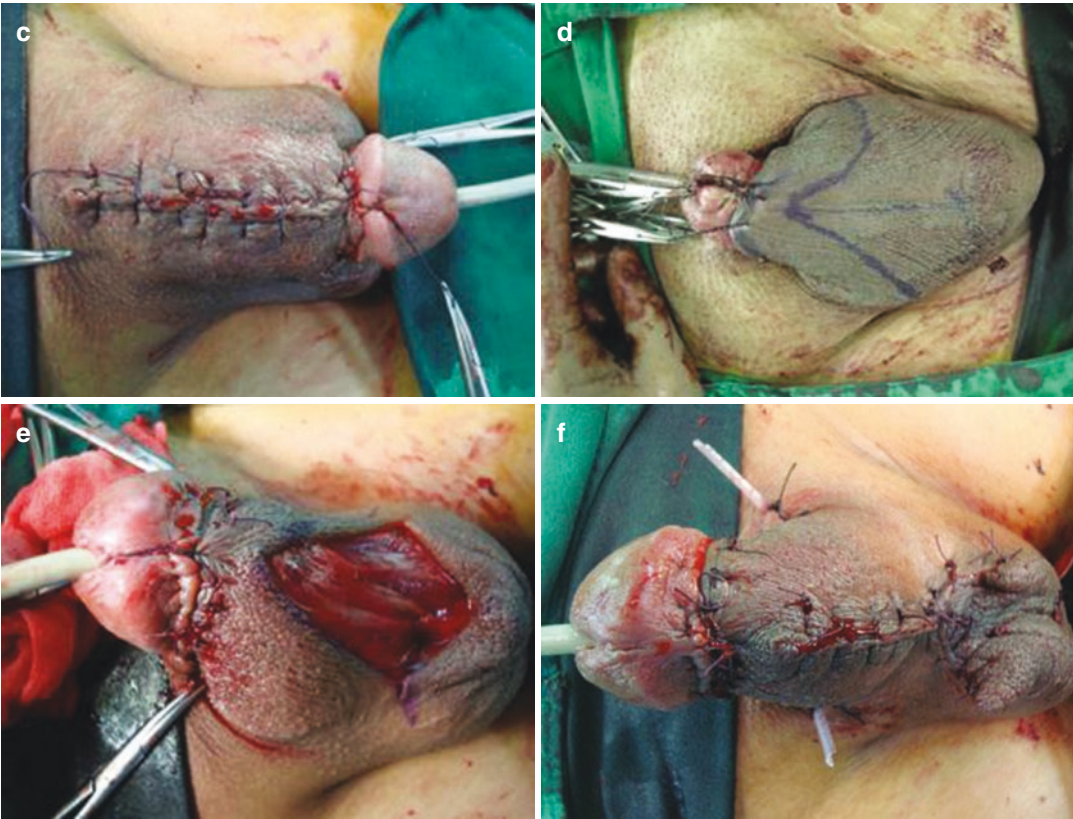


Fig. 59.9 (continued)

59.6 Classification

Sclerosing Lipogranuloma of the penis is not a common condition [6, 14, 22]. Most of the data are from case reports [1]. There has been no widely-accepted classification of sclerosing lipogranuloma offered. Sejbén in 2012 proposed classification into local, locoregional, and systemic forms [23]. This classification also reflects the incidence of each category. In our hospital we use another classification that can be used as a guidance for the management approach of this disorder. In many cases, the disorder is localized in the penis, with or without scrotal and suprapubic fat involvement [23]. The involvement of the surrounding area of injection become the main aspect of the classification, as can be seen in Table 59.3.

Table 59.3 Classification of sclerosing lipogranuloma of the penis

Category 1	Minimal lesion, less than one third of the penis, no suprapubic or scrotal involvement
Category 2	Lesion in the shaft penis, more than one third of the penis, no suprapubic or scrotal involvement
Category 3	Lesion in the shaft penis, with suprapubic involvement, and half or less scrotal involvement
Category 4	Lesion in the penis, suprapubic and more than half of the scrotum

The classification mainly depends on the availability of scrotal skin (Fig. 59.10). Category 1 of sclerosing lipogranuloma of the penis consists of small lesions in the shaft penis, without other areas involvement (suprapubic or scrotal skin). The lesion must be smaller than one third of the



Fig. 59.10 Classification of sclerosing lipogranuloma of the penis. (a) Category 1. (b) Category 2. (c) Category 3. (d) Category 4

penile shaft. Most of the time, category 1 lesions can be treated with simple excision and primary closure. Complication is usually minimal in this category. Category 2 consists of lesion in the shaft penis, without involvement of the scrotum or suprapubic area. In this category the scrotal skin is still in a very good condition, and can be used safely to cover the defect. One stage scrotal flap reconstruction usually can be performed, with very good results. Category 3 involves not only

the penis shaft, but also the suprapubic area, and not more than half of the scrotum. For this category, Cecil's two stage scrotal flap is the safe option. Skin grafting, either full or split thickness, or mesh graft, can also be considered. Category 4 lesions, involves all the penis shaft, suprapubic and more than half of the scrotum. In this category, scrotal flap will be hardly possible to be used. Skin graft, with flaps from the thigh is possibly the best option to correct this abnormality.

59.7 Conclusion

Penile injection with mineral oil is mostly performed by non-medical persons. The effect can be disastrous. The injected materials can not be metabolized by human body, thus foreign body reaction will occur, producing sclerosing lipogranuloma. Chronic sclerosing inflammation will lead to hard nodules, cellulitis, skin ulcer, penile deformity, painful erection, and inability to perform sexual activities.

Surgery is the best viable option to treat this disorder. Complete excision is necessary to remove all the affected tissue and involved regional lymph nodes. Leftover of the granuloma will be the source of recurrence. After the complete excision, the exposed area can be covered by grafts or flaps. In our opinion scrotal flap (direct or staged procedure) is the best choice to cover the defect.

Sclerosing lipogranuloma of the penis is not a common condition. Most of the data are from case reports. A classification system can be used as a guidance for treating the patient.

Key Summary Points

- Mineral oil injection to the penis is an attempt to augment the penile girth.
- Mostly performed by non-medical person, a lot of cases ended with disastrous results.
- Sclerosing lipogranuloma is the result of foreign body reaction cause by the injected mineral oil.
- Surgery is the best option to correct this disorder.
- Correcting this disorder by complete excision followed by covering the defect with grafts or flaps gives a satisfactory result.
- Sclerosing lipogranuloma is classified by the extent of affected area to help treating and reporting this disorder.

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Penile Transplantation: The Last Frontier in Penile Reconstruction

60

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and Alexander Zühlke

60.1 Introduction

The successful transplantation of a human penis potentially changed the genital reconstructive landscape forever [1–3]. For the first time, aphallic patients have the opportunity to have an absolutely normal penis in respect of appearance and function. Normal penile appearance and function cannot be duplicated with phalloplasty or other reconstructive techniques currently available. The so-called “dream” of phalloplasty might be fulfilled by penile transplantation [4]. The goal of performing penile transplantation is to allow the aphallic male to have normal, spontaneous erections for penetrative sexual intercourse, to urinate in a standing position and once again return to a genital identity and -psychological state equal to that of a man with a normal phallus. It would be unethical to perform penile transplantation on demand for individuals who did not suffer penile loss but are simply seeking a larger phallus.

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60.2 Causes for the Absence of a Penis

Causes of the absence of a penis include penile loss secondary to trauma, circumcision – in particular, ritual circumcision with subsequent infection and gangrene, penectomy for penile carcinoma, industrial accidents, congenital aphallia, gender dysphoria in transgender men, surgical disasters such as penile diathermy injuries and amputation by self-mutilation or assault. Depending on the cause, a unique challenge to transplanting of the penis will likely be posed. For instance, radical penectomy for cancer would necessitate a much more proximal approach to penile transplantation than penile amputation secondary to assault. Should a penis be transplanted in transgender men, an even more proximal approach would likely be needed creating challenges regarding blood supply to the corpora cavernosa.

60.3 Contra-indications to Penile Transplantation: Donor

Only anatomically and functionally normal penes should be transplanted. Sexually transmitted diseases have to be clinically and serologically excluded before penile harvesting. Due to the limited numbers of penile transplants performed to date, the ideal donor age is a matter of opinion,

but late teens to the early thirties would seem the ideal age group because penile vascular disease is unlikely to be present.

An intact donor foreskin is not essential for successful penile harvesting and transplantation.

60.4 Contra-indications to Penile Transplantation: Recipient

Not every patient requesting penile transplantation is an appropriate candidate for the procedure. Those with enough remaining penile length to have penetrative intercourse and urination in a standing position possible should not qualify for a penis transplant. Only the most severe microphallus would qualify for surgery. Any condition that might make the adherence to post-operative immunosuppressive regimes difficult would be a contra-indication to further work-up. This includes mental illness, substance abuse and geographical location a long distance from the penile transplant team for follow-up. In our experience patients are willing to move to an area close to the hospital to overcome this obstacle. Active infections of any nature would be a contra-indication. It is not sure whether retroviral status should be a contra-indication per se for medical or ethical reasons: It would be disastrous if an HIV positive recipient infects a partner via a transplanted penis. The risk can be managed by keeping the viral load very low, but there will remain a risk, in particular, if anti-retroviral medication is interrupted for a period.

60.5 Ethical Matters Arising from Penile Transplantation

There has been a “revolution” in organ transplantation with the increasing number of vascularized composite tissue transplantations (VCA) such as hand, forearm and face being performed across the globe [5]. These transplantations are in contrast to solid organ transplantation such as liver, heart or kidney where the recipient would demise if the transplantation is not performed, even though the patient may die because of the surgery. In VCA, the patient’s physiological life is

not at obvious risk. Ironically, toxicity secondary to immunosuppression may cause solid organ failure or death from solid organ failure, infections or cancer in the recipient.

Patients in need of penile transplantation are usually young. This means they have a large quantity of own life that they might be wanting to trade in part for receiving the quality of life made possible by a normal functioning and appearing penis. The ethical question is whether doctors have the right to impose these risks on recipients, also, do doctors have the right to refuse transplantation in all those who qualify based on the assumption that the patient will be at harm from immunosuppression and does not have the right to decide to accept own risks or not. Choices like these are quite common in urology, for instance, a patient with advanced bladder, or prostate cancer might decide to avoid life-prolonging chemotherapy as the side effects might reduce the quality of life of the time left on earth.

Despite risks of failed surgery and toxic immunosuppression, patients are still very enthusiastic about penile transplantation. Immunosuppressive regimes are nowadays focused on minimal toxicity and often attempt to induce graft tolerance. Bone marrow transplantation from the same donor has reduced immunosuppressive needs in many VCA’s. This might induce a state of total or near total graft tolerance by creating chimerism [6, 7]. It would be paternalistic (ethically wrong) to enforce that all qualifying patients cannot be allowed to consider penile transplantation as an option. Patient autonomy, if applied correctly, should allow patients to decide on the trade-off between quantity and quality of life at current levels of immunosuppression toxicity [8]. Informed consent might be difficult due to potential patient selective hearing when risks are explained. However, as transplant workup is a prolonged process and often takes a year or more, there are multiple contact sessions with the opportunity for risks to become clear to the recipient. It should be made clear at all times that the candidate may withdraw from the transplant program in favour of phalloplasty. The importance of maximum effort to obtain full informed consent cannot be overemphasised.

60.6 Harvesting and Preparing the Penis for Allotransplantation

Penile harvesting forms part of multi-organ procurement which often includes solid organs, skin and corneas. Consent to harvest the penis has to be specifically obtained from the grieving family. One cannot expect a family who consented to “all organs” to be content with penile harvesting. To protect the donor’s dignity, the surgical team should offer to create a phallus for the donor by transposing a skin flap from the abdomen down and tubularize it with skin staplers. This takes less than 30 minutes as vascularity of the flap is not necessary. A side table is prepared with ice swabs, ice cold transplant perfusion solution and small vascular cannulas. Fine vascular- and microsurgical instruments must be available. If possible at all, bone marrow should be drawn from the donor for transplantation into the recipient by a haematologist.

When multi-organ harvesting is performed, the surgical team procuring the penis can start simultaneously to the team harvesting the solid organs. The donor will be in the supine position – in addition, for penile harvesting, the lower limbs should be placed in the frog-leg position. Lithotomy is preferred in an obese donor or when proximal corpora are likely to be required for transplantation. A skin incision with a 1–2 cm rim around the penis, similar to radical penectomy, is created. Recipient pathology would dictate the proximal extent of the corporeal transection. In cases of penile cancer where corpora have been in part resected from the pubic bones, one might have to dissect the cavernosal arteries back to the pudendal artery and create a similar dissection in the recipient. However, the maximal length of the dorsal neurovascular bundle should be preserved by meticulous dissection from under the pubic arch. The dorsal arteries of the penis should be identified during the dissection for easier identification and cannulation later on the bench. An important consideration is the fact that dorsal arteries become much wider proximally. A longer vascular pedicle of the donor penis would also decrease

the needed length of the recipient vascular supply (deep inferior epigastric vessels) therefore saving time during the abdominal dissection. The urethra is dissected to the proximal bulb. The dorsal neurovascular bundle is cleanly transected with a scalpel. Proximal corpora and urethra are transected. Bleeding in the donor is controlled by compression until cardiac arrest in the brain-dead donor is established [9].

On the side table, the dorsal arteries of the penis are cannulated and transplant solution flushed through using gravity. Backflow of the infused fluid via the corporeal bodies would indicate a connection between the dorsal vessels and corpora and may have potential benefit for erectile function. If the calibre of the cavernosal arteries is too small to be cannulated, transplant solution should be flushed directly into the corpora using a syringe and needle, similar to the access used for priapism. The penis should be flushed until clear fluid is seen from the corporeal bodies and skin. Using a microscope at adequate magnification, the neurovascular bundle is dissected to identify the arteries, veins and nerves. These structures should be separated for 3–4 cm to allow easier manipulation during anastomoses. The corpora and urethra are trimmed to the expected transplant length needed as dictated by the pathology addressed. The urethra should be about 2 cm longer than the corpora cavernosa to allow for a spatulated anastomosis to the recipient urethra.

60.7 Preparing the Recipient for Graft Attachment

The patient is anaesthetised in the supine position under general anaesthesia with intra-arterial blood pressure monitoring and suprapubic catheter drainage of urine. Maintaining adequate perfusion pressure during and after the transplantation is critical. The local dissection of the genital area will be guided by the recipient’s pathology. A skin incision, circumferentially, to match the calibre of the graft is created. All sizeable blood vessels found in the skin should be carefully identified and dissected free for possible skin drainage of the graft later. All scar tissue must be excised. The

remainder corporeal stump is dissected free until a corresponding calibre to the graft is found. The urethra must be freed and the distal end clean and ready for spatulation before the urethral anastomosis. Troublesome bleeding from these, if present, is controlled with vascular slings.

The dorsal penile nerves of the recipient must be identified in the dorsal neurovascular bundle and dissected free to allow for manipulation during coaptation to the dorsal nerves of the graft. The deep inferior epigastric vessels are a good calibre match for the dorsal vessels of the penis. Blood supply to the cavernosal bodies via the dorsal vessels is probably more common than previously investigated [10]. Incisions over the lateral border of rectus muscles are made to dissect the deep inferior vessels for a distance adequate to transpose them under a skin bridge to the donor vessels. The deep inferior epigastric vessels are dissected free from their origin making sure to prevent kinking when the vessels are brought 180° down. A gentle curve is followed that should improve laminar flow in these vessels. The branches of the deep inferior epigastric vessels must be ligated securely. A bleeder under the skin bridge might cause an unnecessary delay later. The dissection of the deep inferior epigastric vessels continues until adequate length and calibre are achieved.

If the venous match is less than perfect, the long saphenous vein could be dissected and brought into the wound for venous drainage. The deep inferior epigastric artery and vein must be separated with enough space to perform the anastomosis on each vessel without pulling on the other. The artery and vein should be marked anteriorly with a marker pen to prevent twisting when transposed under the skin bridge. Once the deep inferior epigastric vessels are controlled at their origin with vascular clamps, transected at the correct length and flushed with a solution for heparin and saline they are ready to be transposed to the attachment site. This is done by freeing the subcutaneous tissue under the skin bridge and placing a large latex corrugated drain under the bridge. The vessels are then brought into the wound by pulling on the drain, not the vessels. The recipient site is ready when the deep inferior epigastric vessels are in the wound, the corpora and urethra prepared, the dorsal nerves

of the recipient penis identified and bleeding is under control.

60.8 Attaching the Penile Transplant to the Recipient

The cavernosal arteries anastomoses are attempted with 9/0 or 10/0 nylon suture and adequate microscope magnification. It is unsure if the cavernosal anastomosis has a beneficial effect as recanalisation is likely to happen; the time saved not doing it is valuable in an operation that can take 9–16 hours to perform. In the two penile transplantations performed by Stellenbosch University doctors, only one artery was anastomosed. The degree of difficulty of the cavernosal anastomoses should not be underestimated [9].

The dorsal arteries are anastomosed with 9/0 interrupted nylon sutures under microscope magnification. The veins are anastomosed with a coupling device to save time. Clamps on the inferior epigastric vessels are released, and then the arteries are observed for pulsation until their entry into the dorsal neurovascular complex. A Doppler examination to confirm flow will be helpful at this stage as an occluded arterial anastomosis can still transmit a pulse due to a water hammer effect on the thrombus. Backflow of blood via the corpora cavernosa, corpus spongiosum and skin, should be prominent and confirms patency of the arterial anastomosis. The remainder of the corpora cavernosa are closed with 2/0 polyglycolic continuous suture in a watertight fashion. The dorsal nerves of the penis are coapted with 9/0 or 10/0 nylon sutures. The urethra ends are spatulated and a double layer continuous mucosal anastomosis with 4/0 polyglycolic acid is done followed by the outer layers of the spongiosum with the same suture. The corpora cavernosa and spongiosum should be closed watertight allowing for early postoperative erections. Skin blood vessels observed should be anastomosed if proximity allows. Re-routing and tunnelling of the great saphenous vein to enhance venous skin drainage would be time-consuming and is unlikely to have a major benefit. Intra glans tissue oxygen perfusion monitoring is helpful in the immediate postoperative period. The penis is loosely dressed, to

allow for post-operative erections, with a non-sticky silicone dressing and stabilized with a foam sponge tubed over it and stapled to the skin. The penis should be at about 90° to the body. The glans penis should remain visible to check capillary refill and colour. Movement of the penis should be restricted. A cradle is placed under the sheets of the patient making sure no external pressure exerted on the transplant. Heparin anticoagulation is started intra-operatively.

60.9 Post-operative Monitoring

The patient should be in intensive care or a high care isolation ward. It is critical maintaining the blood pressure at around a mean arterial pressure of 100 mmHg to prevent thrombosis and maintain blood flow to the graft. Tissue oxygen partial pressure is monitored; a sudden drop indicates the need for an emergency return to theatre to revise the anastomoses. The transplant is inspected on day three. Possible skin necrosis at the base is monitored, but only debrided from about a week postoperatively to allow for demarcation. In the Stellenbosch cases, there was about a centimetre and a half of the base debrided in the first case and only very minimal debridement in the second case. Swelling of the skin due to lymphatic obstruction should be expected and poses a high risk for infection (Fig. 60.1). Swelling subsides in a few weeks to months. (Figs. 60.2 and 60.3).

A daily dose of oral phosphodiesterase-5 inhibitor is started on day one postoperatively to ensure erections as early post-operatively as possible.

Access to the patient must be limited to two or three team members who also exclusively do the daily dressings (starting after day three), making sure of absolute sterility. The patient should stay in the hospital for more or less 4 weeks, though this lengthy monitoring as part of the research setting is probably overtreatment. A psychologist, preferably the same one as during workup, should visit the patient daily. The tissue perfusion monitor is removed after 4 days and the suprapubic catheter at 6 weeks once a urethrogram confirmed patency with no leaks at the urethral anastomosis.



Fig. 60.1 Swelling of a penile transplant on the thirty-second post-operative day still visible



Fig. 60.2 A penile transplant at 18 months postoperatively

60.10 Immunosuppression

A detailed report is out of the scope of this chapter. Immunotherapy side effects are the price recipients have to pay to receive a perfect penis. These side effects can be fatal. Common side effects include renal failure, infections such as tuberculosis and fungi, malignancies including

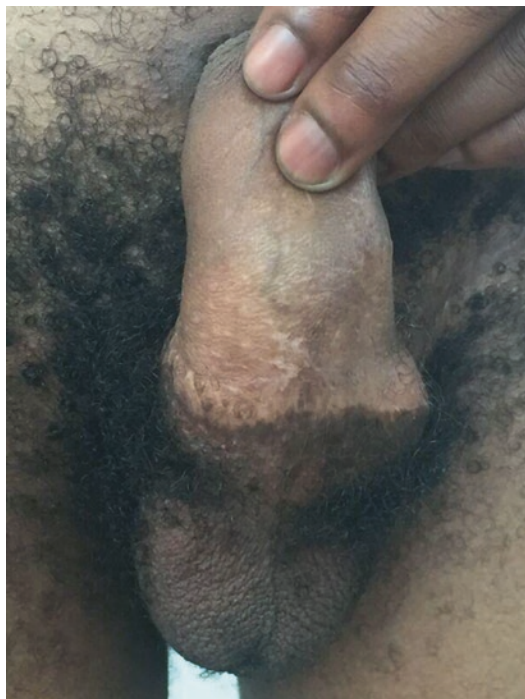


Fig. 60.3 The line of demarcation between recipient and transplant is more visible in the ventral side

haematological cancers and skin changes including abnormal hair growth and pimple like lesions from steroids. The most common reason for non-adherence to the immunosuppression protocol is an objection to skin changes, in particular in younger recipients of solid organ transplants. Patients under the age of 25 are at the highest risk of non-adherence to immunosuppression regimes [11, 12]. Reducing immunosuppression toxicity is of paramount importance. If this can be achieved by concomitant same donor bone marrow transfusion, it will be a major step forward in the long-term health of the recipient. Drug requirements could be significantly reduced as a degree of graft tolerance may be achieved using simultaneous bone marrow transplantation. Close monitoring of blood levels to prevent toxicity is vital. Standard induction regimes could be adapted to local needs by the attending transplant immunologist. Routine- or sentinel biopsies are potentially dangerous and might not yield the information needed in respect of early rejection.

60.11 Conclusion

Penile transplantation has come to stay. While donor shortages will likely impede the frequency of transplantation, a new gold standard in genital reconstruction has been set. Toxic immunosuppression is a barrier to penile transplantation. However, toxicity can be reduced by administering modern regimes including concomitant bone marrow transfusion. At current levels of immunosuppression toxicity, qualifying patients have the right of autonomy to accept these risks if their penis defect cannot be reconstructed or if the penis is absent.

Key Summary Points

- Penile transplantation is feasible, but one of the more challenging genito-urinary reconstructive surgeries due to the protracted work-up and challenging harvesting as well as transplantation surgery.
- The need for penile transplantation may be increased due to war related injuries.
- The young braindead donor needs to have a normal penis and be free of infectious diseases and cancers.
- Immunosuppression might cause solid organ failure and malignancies in the recipient.
- Despite the risks of immunosuppression and failed surgery patients are very enthusiastic about penile transplantation.
- Ethical considerations evolve around “first do no harm” and patient autonomy. Informed consent is essential.
- Harvesting the penis should be done with great care to preserve the essential structures needed to anastomose to the recipient stump.
- The penis should be cooled to about 4 °C prior to storing in an appropriate transplant solution on ice while the recipient is prepared.

- Creating a good blood supply is essential to survival of the transplant.
- Post-operative monitoring tissue oxygenation and blood pressure monitoring is essential. Fluctuations in blood pressure should be avoided as this risks thrombosis of the vascular supply of the graft.
- A transurethral catheter should be avoided. Place a supra-pubic catheter.
- Adhering to the immunosuppression regime is essential for penile graft survival.

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Part III

Urinary Incontinence and Neurourology

Surgical Treatment of Male Stress Urinary Incontinence: An Overview

61

Jaspreet S. Sandhu

61.1 Introduction

The most common cause of male stress urinary incontinence (SUI) in patients who seek treatment is prior prostate treatment, particularly radical prostatectomy [1, 2]. The fact that these patients have already suffered an adverse event is an important factor to consider when offering surgical treatment for incontinence. Therefore, patient counseling and managing patient expectations is nearly as important as outcome in the traditional sense after surgery for SUI. All patients should be told about the natural history of urinary function recovery, ideally prior to prostate cancer treatment, and then undergo conservative measures to hasten urinary continence. About 10% of patients will, unfortunately not regain continence and about half of these will seek treatment [3].

All patients should have already undergone a course of pelvic floor muscle exercises or physical therapist-direct pelvic floor muscle therapy. Prior to offering surgical therapy, patients should be beyond an appropriate period to make sure continence will not return (usually 6–12 months) and continence level should be at a plateau.

Furthermore, other pathology including overactive bladder or anastomotic stenosis should be ruled out or treated. Once it is determined that the patient is suffering from intractable SUI or stress-predominant SUI and is significantly bothered, surgical management should be offered to the patient.

61.2 Surgical Management

After surgical treatment for stress urinary incontinence is chosen by the patient and his provider, the patient must be counselled on the myriad of treatments available, their risks, outcomes, complications, and alternatives available [4]. Furthermore, some surgical modalities are better suited for specific patients based on the degree of incontinence, history of radiation therapy, history of anastomotic stenosis – treated or not, and the quality of the bladder. Another consideration is the general health of the patient because most surgical procedures require regional or general anesthesia.

61.3 Urethral Bulking Agents

The least invasive treatment for SUI consists of urethral bulking agents [5]. Urethral bulking consists of injecting bulking material via an injection needle introduced through a cystoscope. The

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injections are typically sub-epithelial near the location of the bladder neck. Multiple types of injectable material have been used. Collagen was one of the first materials used, but because it is absorbable, multiple treatments were needed over time to maintain efficacy. Unfortunately, efficacy was only seen in less than 20% of patients with a large proportion of the responders needing retreatment [6].

Subsequently, non-absorbable agents have been used (eg. Carbon-based gels) for urethral bulking [5, 7]. The rationale for these was to decrease the number of times that patients would need to be retreated. No large series exist, but the consensus among those that perform these procedures is that these agents also need to be retreated and their results are essentially the same as that with collagen.

Urethral bulking agents are not considered durable treatment for SUI, but they can be used if patients are aware of their low efficacy and their high rate of retreatment. They can also be used in patients who are not candidates for regional or general anesthesia or as a bridge to definitive treatment. Furthermore, the use of bulking agents does not preclude the use of other surgical procedures.

61.4 Male Slings

Male slings are treatment for SUI that consists of placing a mesh underneath the urethra usually through a perineal incision [5, 8]. Male slings are generally either fixed, with transobturator or quadratic slings being the most common current variants, or adjustable. The most common male sling, the transobturator male sling consists of mesh “arms” that become embedded in native tissue and are therefore considered fixed. Adjustable male slings are those that contain mechanisms that allow the slings to be tightened after initial placement. These slings, in theory, allow for better efficacy because they can be tightened in patients who are unhappy with continence results after the procedure. Mesh material is generally large-pore polypropylene but can also be silicone or other materials.



Fig. 61.1 Placement of transobturator male sling under the bulbar urethra with trocars attached to mesh arms

Male slings are considered “minimally-invasive” because they generally require a small perineal incision and often trocars introduced through separate stab wounds that are used to place the arms of the mesh (Fig. 61.1). They are usually performed with regional or general anesthesia, but sometimes can be performed with sedation and local anesthesia. While there are no specific contra-indications, multiple reports show that male slings lose efficacy in patients with a history radiation therapy and are not as objectively effective in patients with severe degrees of incontinence. In patients with very mild incontinence (eg less than one pad per day of SUI), patients should be counseled that the slings are very effective but that there is a risk of dissatisfaction if they do not result in the patient being completely dry and therefore caution should be used in this cohort. As a rule of thumb, male slings are considered very effective for patients with mild to moderate urinary incontinence and no history of radiation therapy and should be offered to these patients.

Other than the risk of inadequate continence recovery, patients should be counseled about complications after male sling placement. Mesh infections or urethral erosion, while rare, require removal of at least the offending part of the mesh. In this instance, removal of foreign body (mesh material), followed by debridement and possible urethroplasty are needed. Furthermore, patients are left with SUI at least as severe as

pre-male sling and cannot undergo another procedure for SUI for at least 3 months. For those dissatisfied with the continence results after male sling surgery, a repeat male sling with or without excision of previously placed sling can be offered. This is a difficult operation and should likely be restricted to surgeons with significant experience in re-operative sling surgery [9]. An artificial urinary sphincter (AUS) can also be offered to these patients, as some may now be willing to consider this procedure. In this instance, reoperation, while somewhat more difficult than a virgin AUS is reasonably straightforward partly because the male sling can be left in-situ if it does not interfere with the placement of the urethral cuff [9, 10].

61.5 Artificial Urinary Sphincter

The artificial urinary sphincter (AUS) is considered the gold standard treatment for SUI [11]. Multiple modifications of the AUS have been made to this device since it was introduced in the early 1970s. The current version is essentially a fluid transfer system consisting of three components – a urethral cuff, a pressure regulating balloon, and a control pump (Fig. 61.2). Patients undergoing the AUS must have cognitive and physical ability to use this device and must be reasonably able to do so for the near future. It is

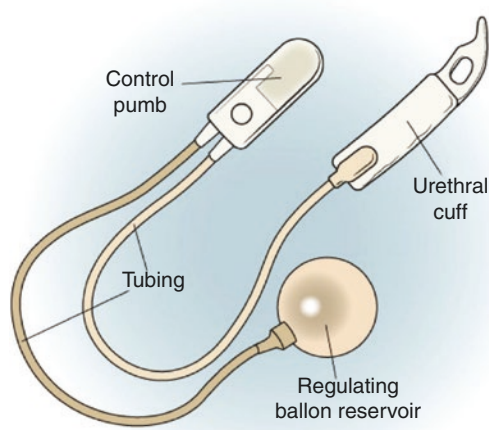


Fig. 61.2 Components of an artificial urinary sphincter

usually performed with general anesthesia through a perineal approach (Fig. 61.3) with a counter-incision in the abdomen for placement of the pressure-regulating balloon (Fig. 61.4) [11, 12]. There are other surgical approaches that can be used including the transverse scrotal approach or the laparoscopic approach. The AUS can be used in almost all patients with stress urinary incontinence, including those with a history of RT and those with severe SUI. However, caution should be used in patients with recurrent or refractory post-prostatectomy anastomotic stenosis.

Patient counselling is critical for patients who choose to proceed with an AUS. “Social continence,” generally thought of as the need for one pad or less per day to control urinary incontinence, is considered a success after an AUS by most authorities. This means that all patients undergoing an AUS should be told to expect to



Fig. 61.3 Placement of urethral cuff through a perineal incision



Fig. 61.4 Abdominal counter incision to develop sub-rectus space for placement of pressure regulating balloon

leak up to one thin pad per day. This is in distinction to male slings where success is usually considered no urinary leakage at all.

The need for subsequent surgery following AUS implantation also needs to be made clear. Complications of AUS including infection, cuff erosion, and device malfunction all lead to reoperations [11, 13]. Lack of adequate improvement in continence can also lead to further surgery. Infections after AUS are not common but when they occur, the device needs to be completely explanted. Cuff erosion, usually due to urethral instrumentation (eg urethral catheter, cystoscope) also requires explantation of the entire device along with placement of a urethral catheter for a few weeks with or without urethroplasty. After an infection or erosion, repeat AUS surgery should be delayed by at least 3 months.

Patients should be counseled that the AUS is a surgical device and as such has a finite lifespan. The median time to failure is 8–10 years [13, 14]. Device malfunction of an AUS presents with sudden worsening of urinary continence and is often due to a leak of fluid from anywhere in the system. This can be confirmed by cross sectional imaging to document decreased or no fluid in the AUS pressure-regulating balloon (ie fluid reservoir) [15]. In the setting of a device malfunction, patient counseling should again be undertaken and if the patients wishes to replace the device, an explant and replacement procedure can be performed in the same setting.

It is important to note that secondary AUS surgery has similar complication rates as primary AUS surgery with the exception of patients undergoing AUS after erosion [16], in which case reoperations can be expected sooner and these patients tend to have a slightly higher rate of subsequent urethral erosion.

61.6 Other Procedures

There are a host of newer agents available for SUI such as adjustable sub-urethral balloons. The longitudinal efficacy and complications associated with these procedures have been reported and should be relayed to patients if these procedures are chosen. Unfortunately, the data regard-

ing complications and reoperations is not mature enough for many other newer devices and therefore these should probably be limited to surgeons with experience or perhaps on clinical trials.

A number of procedures for SUI have been abandoned over the years but a knowledge of these procedures is important should a patient present with recurrent SUI years later. In particular, if there is material left around the bulbar urethra (eg after bone-anchored male sling), then this material may been to explanted prior to performing additional surgery for SUI.

61.7 Conclusion

In summary, there are a host of options available for men suffering from SUI. All of these procedures are elective and for an iatrogenic condition mandating shared decision making between the patient and his doctor. Patients should be extensively counseled regarding the risks, benefits, alternatives, and durability of any procedure offered for SUI.

Key Summary Points

- Radical prostatectomy is the most common cause of male stress urinary incontinence.
- Pelvic floor muscle exercises should be offered to all patients after radical prostatectomy and those seeking improvement in post-prostatectomy stress urinary incontinence.
- Injection of urethral bulking agents, while easy to perform, is not very efficacious or durable and will need to be repeated.
- Male slings can be offered to patients with mild to moderate stress urinary incontinence and no history of radiation therapy.
- Artificial urinary sphincter is the gold standard treatment for male stress urinary incontinence in almost all settings and certainly in the re-operative setting.

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Treatmente of Male Stress Urinary Incontinence: The AdVance Transobturator Male Sling

62

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62.1 Introduction

The AdVance transobturator male sling (Boston Scientific, Marlborough, MA) is a synthetic sling used for the treatment of male stress urinary incontinence (SUI). Its use was first described by Rehder and Gozzi in 2007 in Austria [1], and since has widely been accepted as a treatment for mild to moderate post-prostatectomy incontinence (PPI) and male SUI [2].

In this chapter, we will discuss [1] the mechanism of action of the AdVance male sling [2], indications for its placement and patient selection [3], step-by-step surgical technique [4], management of possible complications, as well as [5] post-operative care.

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62.2 Mechanism of Action

Before considering placement of an AdVance sling in a patient, the surgeon must be knowledgeable about the perineal anatomy as well as the sling's mechanism of action, as this will guide proper placement of the device.

Contrary to the female transobturator sling, the AdVance transoburator sling relies on strongly on tension and compression to provide relief of incontinence. In fact, several mechanisms of action come into play. After complete liberation of the central tendon – which allows for complete mobility of the urethral bulb – the appropriately located and tensioned sling will relocate the urethral bulb 2–4 cm proximally into the pelvis. This allows for “dynamic compression” of the urethra during periods of increased intra-abdominal pressure (a phenomenon which has been observed on ultrasound studies) [3, 4]. The AdVance sling also provides anatomical support to the membranous urethra, acting as a barrier during stress maneuvers. This is achieved, however, without causing obstruction, as has been proven on pre and post-sling urodynamic studies [5].

Unlike the artificial urinary sphincter (AUS) AMS 800 (Boston Scientific, Marlborough, MA), the AdVance does not provide circumferential spongiosal and urethral compression, and therefore relies on healthy bulbar tissue to provide the bulk required to adequately compress the urethral lumen [4].

62.3 Indications and Patient Selection

Patient selection is very important for post-operative AdVance sling success, and the following criteria must be followed when selecting an appropriate patient for this procedure.

62.3.1 Type of Incontinence

The AdVance sling is a treatment for male SUI. The most common cause of male SUI is PPI in men who have been treated surgically for prostate cancer. However, other urologic surgeries, such as transurethral resection of the prostate, may occasionally lead to SUI. Certain medical conditions such as spina bifida and other types of neurogenic lower urinary tract dysfunctions may also cause SUI [6–12].

Proper patient questionnaire and physical exam, as well as cystoscopy and urodynamic testing if indicated, allow the treating urologist to adequately diagnose the patient's type of urinary incontinence. In patients with mixed urinary incontinence, a trial of medications to treat overactive bladder (OAB) – such as antimuscarinics, beta-3 agonists or other OAB therapies – may be useful before embarking on invasive surgical intervention for the stress component of their urinary incontinence.

62.3.2 Severity of Incontinence

As previously stated, the AdVance sling is indicated for men suffering from mild to moderate SUI [2]. Classically, mild incontinence is defined as a 24-h pad weight test of 150 g or less, and moderate incontinence as a pad weight ranging from 150 through 400 g [13, 14]. However, studies have shown decreased success rates when the 24-h pad weight surpasses 200 g [12, 15].

In the authors' practice, 24-h pad weight testing is deemed cumbersome and time consuming. The validated questionnaire proposed by Nitti and colleagues in 2014 is a more practical way to

assess severity of incontinence [16], and therefore is the evaluation tool of choice for the authors.

62.3.3 History of Radiation Therapy

Patients with a history of pelvic radiation therapy are not good candidates for the AdVance sling, as outcomes are much worse than for patients who have not had any pelvic radiation [3, 17–19]. As such, we advise these patients to consider other treatment options, such as the AUS. Hypotheses for reduced success after radiation include limited urethral mobility and proximal relocation of the urethral bulb when tensioning the sling, as well as inhibited tissue healing and scarring of the mesh into place [20].

62.3.3.1 Pre-operative Evaluation and Ancillary Testing

Mandatory pre-operative evaluation, in the authors' opinion, consists of a full history and physical exam, uroflowmetry and post-void residual (PVR) and a urine culture.

If any signs or symptoms of obstruction exist, this would prompt a pre-operative cystourethroscopy to rule out vesicourethral anastomotic stenosis (VUAS) or urethral stricture prior to placing the AdVance sling. The authors also recommend a routine pre-operative cystoscopy in any patient with a history of open radical prostatectomy (RP) as the risk for VUAS is significantly higher in this patient population when compared to patients who underwent laparoscopic or robotic RP [21–23]. **If urethral stricture or stenosis is present, it is advised to treat and stabilize this for 3–6 months before sling placement.** Cystoscopic confirmation of a patent urethra or resolution of VUAS is recommended before proceeding to sling insertion.

Urodynamics may also be helpful in certain men who do not have a straightforward history. In fact, among patients with lower urinary tract symptoms (LUTS) after RP, 41% had detrusor underactivity (DU), 27% had detrusor overactivity (DO) and 17% had evidence of bladder outlet obstruction [24]. As mentioned above, a trial of

OAB medications may be warranted in patients with mixed urinary incontinence. Treatment of the urge component may reclassify the patient in to lower incontinence category and change his treatment options for the stress component, or completely obviate the need for surgical treatment. Furthermore, presence of DU is a risk factor for post-sling urinary retention [25] and DO is a negative prognostic factor for success [3, 7].

Urodynamic testing should be performed pre-operatively in all patients with neurogenic bladder who are candidates for a sling and should be performed on a routine basis post-operatively, along with upper tract imaging to survey for hydronephrosis and upper tract deterioration. Patients who perform clean intermittent catheterisation may still do so after sling placement but should be advised that it may be more difficult to perform. Changing catheter types to a smaller size or a coude tip may help overcome this issue.

A pre-operative urine culture is always obtained, and if positive is treated appropriately for at least 48 h before surgery.

62.3.3.2 Surgical Technique

Briefly, AdVance sling placement involves the following steps: (1) corpus spongiosal dissection and mobilization; (2) identification and release of the central tendon; (3) placement of needle passers through the obturator foramen; (4) mesh fixation at central tendon; (5) mesh tensioning and cystoscopy; (6) incision closure [26]. Key points are detailed in Table 62.1.

Laryngeal mask anesthesia (LMA) or spinal anesthesia is preferred for this procedure, to avoid excessive coughing that may occur with endotracheal extubation, as this may loosen the sling. Antibiotic prophylaxis is given that will cover skin flora as well as genitourinary pathogens, such as an ampicillin-aminoglycoside

Table 62.1 Key points of surgical technique and details of nuances for AdVance sling placement

<i>Key points of surgical technique</i>
Ensure complete dissection of the central tendon off the corpus spongiosum
When placing the needle, have it emerge from the most apical point in the angle between the corpus spongiosum and inferior pubic ramus
Secure the sling in ideal location on the bulbospongiosum, at the level of the central tendon
Guard against urethral injury
Take care not to button-hole the bulbospongiosus muscle with the trocar
Obtain good urethral coaptation at the level of the external sphincter
Tunnel the mesh arms subcutaneously to the midline perineal incision
<i>Further nuances</i>
Dissecting to expose the lateral aspects of the bulbar corpus spongiosum can help you identify the apex for needle passage
For optimal apical needle placement, after you have felt the two “pops”, ensure that you drop your hand which is holding the trocar handle from a 45° to a 90° angle downward when passing the needle through
Place a marking suture (4-0 Vicryl) or use a marking pen at the site of the distal extent of the central tendon as soon as you have dissected this part of the central tendon off the corpus spongiosum. The site of this marking suture will be the future site where the proximal edge of the body part of the sling will be secured
Hold a finger of your contralateral hand on the side of the corpus spongiosum, to protect it from the approaching trocar needle
Placing an Allis clamp onto the edge of the bulbospongiosus muscle can help you retract it outward away from the site of needle passage, to prevent buttonholing the muscle
Pull up on the bilateral sling arms simultaneously and firmly. This can be done with a cystoscope in place observing for good coaptation of the sphincter complex. Ensure that a 12–14 F Foley urethral catheter is able to be introduced through the urethra after tensioning the sling but prior to closing the surgical wound in case the sling needs to be adjusted or loosened
Burying the sling arms can be performed with the aid of a tonsil clamp and reduces the risk of slippage of the mesh

combination [27] or a first-generation cephalosporin.

Surgical positioning is of utmost importance to allow for proper passage of the needles. The patient is placed in a dorsal lithotomy position, with hips and knees flexed at 90° and knees at a shoulder-width distance. To facilitate needle entry without obstructing the surgeon's hand – especially in obese patients – the patient's buttocks may slightly hang off the end of the table. Standard surgical skin asepsis is performed, and sterile drapes are applied ensuring that the anus is properly covered to prevent contamination.

A 3–5 cm midline perineal incision is made. A Scott retractor may be used for improved traction and visualization. The bulbospongiosus muscle is identified, then opened midline to reveal the corpus spongiosum (CS). The CS is dissected bilaterally, distally, and proximally until the central tendon. The distal aspect of the central tendon is marked with a marking pen or an absorbable suture, then is completely released off the CS until the bulb of the urethra is completely mobile (Fig. 62.1a, b).

Next, the Scott retractor is removed, and two puncture wounds are performed in either groin crease, just lateral to the ischiopubic rami. There is a “soft spot” that is palpable 1–2 cm below the adductor longus tendon, and these areas should be symmetric. A spinal needle may be used to confirm correct placement of these helical needle insertion sites. The needle tip is inserted into the puncture wound at a perpendicular angle with the skin, while the handle of the needle is held at a 45° angle (Fig. 62.2). The index finger from the surgeon's contralateral hand is placed in the perineal incision to protect the CS and guide the needle into the perineum, at the apex formed by the inferior pubic ramus and the CS. The thumb from this contralateral hand is used to place pressure on the helical needle as it is inserted. Two “pops” are felt as the needle is slowly inserted. The tip of the needle should then be palpable in the perineal incision. Before commencing rotation of the needle, the surgeon's ipsilateral hand holding the needle handle is dropped to a 90° angle. Rotation of the needle is then performed, ensuring that the needle tip is exiting right at the aforementioned apex for proper placement (Fig. 62.3). The sling

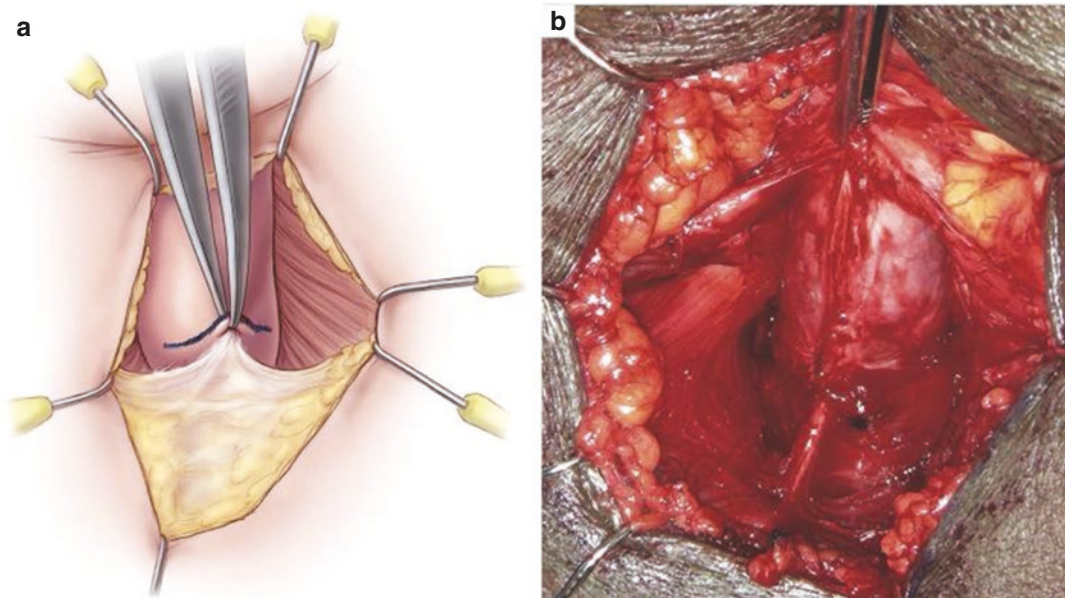


Fig. 62.1 (a, b) The corpus spongiosum at the level of the central tendon is marked with either an absorbable suture or marking pen before the central tendon is dissected off the corpus spongiosum

Fig. 62.2 The trocar handle is held at a 45° angle, the trocar needle point is oriented perpendicular to the patient's skin, and surgeon's contralateral hand is suitably positioned for safe trocar insertion, protecting the corpus spongiosum

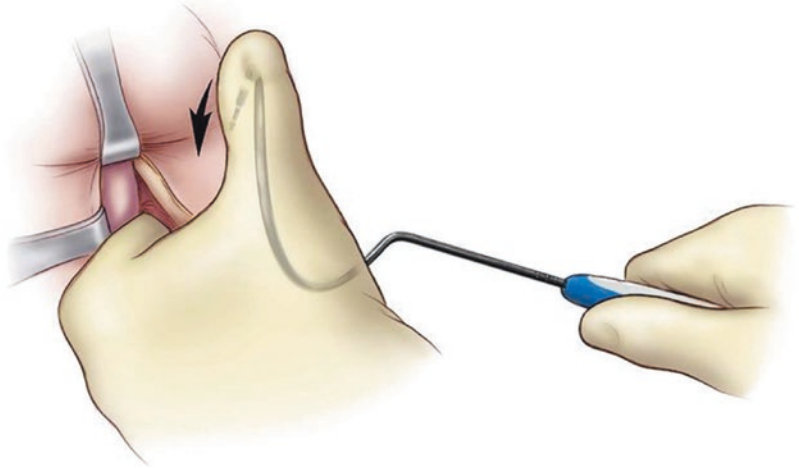
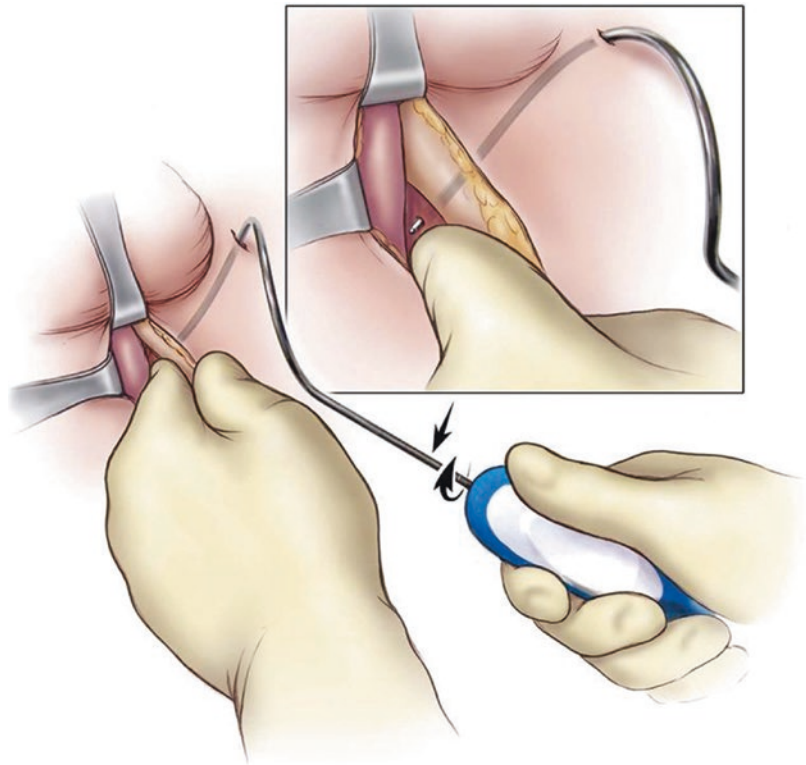


Fig. 62.3 After the two “pops” are felt, the trocar is turned, and the ipsilateral hand of the surgeon is dropped so that the point of the trocar needle is brought out as high as possible in the angle formed by the ischiopubic ramus and corpus spongiosum



is fixed to the needle and brought back through the stab incision. The same procedure is performed on the contralateral side. It is important to ensure that the sling is not twisted, and that the body of the sling lies flat over the CS. The body of the sling is then fixed to the CS, with the proximal edge of the sling sutured to the distal edge of

the central tendon, which was previously marked during its dissection. Two to three interrupted absorbable sutures (4-0 vicryl or PDS) are used on either edge of the sling body (Fig. 62.4).

The sling is then tensioned by pulling firmly and simultaneously on the sling arms (Fig. 62.5). Flexible cystoscopy is performed during

Fig. 62.4 Sutures are used to fix the central portion of the mesh to the corpus spongiosum with the proximal edge of the mesh being fixed at the level of our previous marking where the central tendon had been dissected off the corpus spongiosum

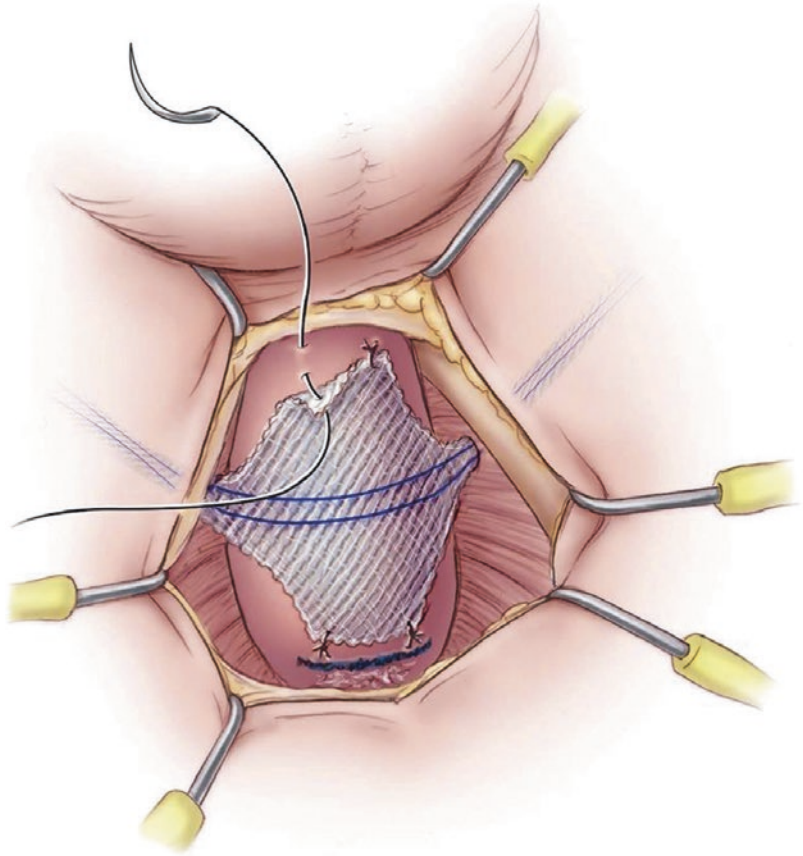
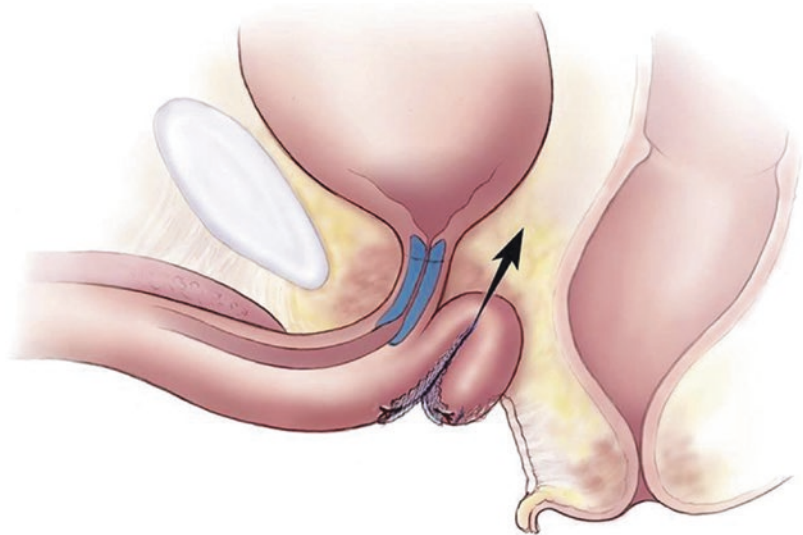


Fig. 62.5 Pulling firmly on the sling arms tensions the sling



tensioning to ensure complete coaptation of the urethra at the level of the external sphincter, and to rule out urethral injury. If complete coaptation is not seen, this is usually because the sling has been placed too proximally. The sutures must therefore be released, and the sling replaced 0.5–1 cm more distally. The tensioning and cystoscopy are then repeated until adequate coaptation is achieved. A small caliber (12 or 14-Fr) urethral Foley is placed immediately after tensioning.

The plastic covering of the sling arms is removed, and the sling arms are tunnelled with the aid of a tonsil clamp. Excess length of the sling arms may be tailored off or, alternatively, sutured together via the midline perineal incision. The bulbospongiosus muscle is reapproximated, then Colles fascia and the skin are closed. The bilateral stab incisions are closed with a simple absorbable suture.

62.3.3.3 Post-operative Care

In the authors' practice, the patient remains in hospital overnight with a small caliber Foley to gravity drainage. A voiding trial is performed the following morning, then the patient is discharged home. **If urinary retention occurs, a small caliber Foley is replaced, and the patient is sent home with a scheduled voiding trial in clinic in 5–7 days.** If retention persists, the patient may begin clean intermittent catheterization, or subsequent voiding trials may be performed at weekly intervals until spontaneous voiding is recovered. Early post-operative retention has been associated with higher success rates, and hence patients should be reassured if this occurs [27]. Risk of long-term retention is very low, and in rare cases lasting longer than 3 months, the sling may be surgically excised.

Post-operative pain is usually minimal, and only a small number of opioid tablets are typically prescribed. A laxative should also be prescribed, to prevent straining during bowel movements which may loosen the sling. **It is imperative that the patient follows post-operative instructions,**

which are to avoid any physical exertion, any lifting heavier than 10 lbs., and no squatting or climbing for 6–8 weeks after surgery. Patients who do not follow these recommendations are at high risk of de-tensioning their sling and failing their surgical procedure. Patients with neurogenic conditions must be cautious not to physically exert themselves during transfers and would benefit from increased caretaker aid or recovery in a rehabilitation center.

Unintentional physical activity may sometimes occur. If the patient reports an initial dry period, followed by a recurrence of their incontinence after physical exertion during the initial 6-week period, a repeat sling placement may be attempted. Re-exploration through the previous incision is performed, and the CS is dissected until the sling is visible. The mesh arms are identified bilaterally and transected, which allows the urethra to be pulled down. The body of the sling is then dissected off the CS and excised. A new sling is then placed in the same manner as described above. The arms of the prior sling to not have to be completely removed, as this would be quite difficult, does not impair proper placement of the new sling, and infection has not been reported.

62.3.3.4 Complications

Overall complication rates for the AdVance sling are low, quoted at 12.3% in a systematic review [11]. Severe complications, including both intra-operative and post-operative events, are rare [11, 28].

The main potential intra-operative complication is urethral injury during passage of the needles. In the authors' experience, this has only happened in two patients early in the AdVance sling "era."

The most common early post-operative complication is urinary retention, occurring in 12–46% of patients. As previously stated, patients with early post-operative urinary retention generally have good outcomes, including resolution of the retention within the

few weeks following surgery and increased long-term continence rates [27, 29]. The long-term risk of chronic urinary retention is very low [28–30]. One reported patient required transection of their sling due to slippage of the sling from its original position, causing obstruction and retention [28].

Other early post-operative complications are rare and include local surgical-site infection (0.4%), febrile urinary tract infection (0.4%) [28] and a case of a hematoma requiring a blood transfusion in a patient who received early re-anticoagulation [31].

Late post-operative complications are equally rare. One patient reported persistent moderate perineal pain [28]. Another patient with a history of pelvic radiation therapy suffered urethral mesh erosion [32]. Sling explantation is very rare (0.9%); one study reported an explantation due to initial misplacement of the sling and another case due to symphysisitis attributed to Guillain-Barre syndrome (and not sling infection) [28].

62.3.3.5 Management of Incontinence After AdVance Sling

Precise success rates after AdVance sling are difficult to quote, as definitions vary between series. Most series define success as equal or less than one pad per day. Success rates vary from 54.5% to 80% [33], however these numbers include some patients with prior radiation, and it has been shown that history of radiation therapy negatively impacts post-operative success and satisfaction rates [34].

To better manage patients with incontinence after AdVance sling, it is important to discern between persistent and recurrent incontinence. Persistent incontinence suggests ongoing SUI and intrinsic sphincteric deficiency and may require further outlet procedures, such as implantation of an AUS. Recurrent incontinence, especially if occurring outside of the initial 6-week window where any physical exertion may loosen the sling, may represent development of an underlying pathology such as DO/OAB. Urodynamics may be useful in this patient population.

AUS implantation is the “gold standard” treatment for SUI after a failed AdVance sling. The sling does not have to be removed during the AUS procedure, as the AUS cuff can be placed distally to the sling body. Up to 13% of men eventually proceed to AUS placement after AdVance sling [35]. AUS placement in this patient population bears a success rate of 80–90%, and success rates are similar between patients with a virgin AUS versus those with a salvage AUS after a failed sling [36].

The authors’ group has also performed cases of salvage AdVance sling placement in cases of late failure after initial primary AdVance sling placement [37]. Success rates were 72% at 6 months and 56% at mean 17.5 months of follow-up. Complication rates were low. Patients who failed late (>6 months) after their primary sling had better outcomes with salvage sling placement compared to patients who failed earlier after their primary sling (75% vs. 30%, $p < 0.05$). This may be because patients who failed late were probably initially better candidates for sling placement than their counterparts.

Placement of a second AdVance sling is done in a similar manner to an initial sling placement with only several nuances in technique. We have found it slightly easier to begin the dissection further distal on the CS in a virgin plane. We mobilize the CS a little more distally than usual. Once the distal aspect of the sling is identified, we are able to place a right-angle clamp around the sling arms and transect them, allowing the CS to move toward the surgeon. We then excise the previous sling off the CS (Fig. 62.6). This is usually difficult, and we occasionally inadvertently enter the CS but have not injured the urethra during the dissection. Any CS openings are closed with an absorbable suture. The trocar needles are passed as previously described and the sling is placed usually slightly distal to the first sling.

Soljanik et al. also reported outcomes after repeat AdVance sling whereby the first sling was left in place and did not prohibit the placement of the second sling. At mean 16.6 months’ follow-up,



Fig. 62.6 The previous AdVance sling is dissected off the corpus spongiosum after the sling arms have been transected lateral to the corpus spongiosum which allows the corpus spongiosum to move toward the surgeon

34.5% men required no pads, 37.9% had one dry “security” pad, 3.4% one wet pad, 3.4% two pads, 10.3% pad reduction $\geq 50\%$, and 10.4% treatment failure [33].

In the authors’ experience, mild persistent incontinence after AdVance sling may also be managed with injection of urethral bulking agents, such as Macroplastique (Uroplasty, Inc., Minnetonka, MN), at the area of coaptation with relatively good results.

Another option to consider would be insertion of ProACT™ balloons (Uromedica, Inc., Plymouth, MN). Al-Najar et al. used the ProACT™ system in ten patients with persistent incontinence after their sling. At mean 6 months follow-up, all ten patients were pad free [38]. The ProACT is not currently available in the United States of America.

62.3.3.6 AdVance XP

Since 2010, the second generation of the AdVance sling, the AdVance XP, has become available in several countries, though it is not currently approved by the Food and Drug Administration (FDA) in the USA. The AdVance XP features different characteristics, including: updated mesh waves with integrated tensioning fibers to stabilize sling configurations upon implantation; longer sling arms; the addition of chevron anchors

on the sling arms, which are intended to provide enhanced acute tissue fixation; Tyvek liners to prevent the chevrons from tearing the plastic sheath; and redesigned helical needles to allow easier tunneling particularly in patients with large body habitus.

The 2-year and 36-month reports of a multicenter study of the AdVance XP sling showed good and stable effectiveness, with 66% of patients cured (using a strict definition of no pads and 0–5 g in the 24 h pad test) and 23.4% improved at 36 months [2, 6, 39]. The only unique intraoperative problem reported in this study was difficulty removing the Tyvek liners in a few cases, which resulted in over-tensioning of the AdVance XP sling.

62.4 Conclusions

AdVance transobturator sling is best suited for treatment of mild to moderate SUI in male patients. Preoperative patient selection is important for operative success and involves exclusion and prior treatment of urethral stenosis and bladder dysfunction. Patient with prior pelvic radiation have poorer outcomes and should be considered for AUS instead.

Sling placement involves the following steps: [1] corpus spongiosal dissection and mobilization [2]; identification and release of the central tendon [3]; placement of needle passers through the obturator foramen [4]; mesh fixation at central tendon [5]; mesh tensioning and cystoscopy [6]; incision closure.

Management of sling failure includes AUS, repeat sling, urethral bulking agent, and ProACT device treatment options. The AdVance XP sling is placed in similar fashion to the AdVance sling and may have increased success rates when compared to the original model.

Conflicts of Interest M Aubé, AS Chung and OA Suarez have no conflicts of interest to declare. KA McCammon is a consultant/advisor and meeting participant/lecturer for Boston Scientific; he is involved in scientific study/trials with Allergan, Astellas, Boston Scientific and Solace.

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63.1 Introduction

Post-prostatectomy incontinence (PPI) accounts for the majority of male stress urinary incontinence (SUI) and is a debilitating condition. Stress urinary incontinence may occur in vary degrees after undergoing radical prostatectomy (RP) for prostate cancer or after transurethral surgery for benign prostatic disease. Stress urinary incontinence is defined as leakage associated with increases in intra-abdominal pressure during physical effort or exercise, coughing, sneezing and lifting [1, 2]. The incidence of SUI is much greater in women than men; however, as prostatectomy has become an increasingly ubiquitous treatment for prostate cancer so has the amount of men reporting SUI up to 60% following RP [3]. Rates of persistent SUI after radical prostatectomy, open and laparoscopic approaches combined, 12 months post-operatively are 16% (range 4–31%) [4]. These rates vary widely between reported series due to variation in measuring the amount of urinary leakage and study populations. Highlighting possible underdiagno-

sis and underreporting, only an estimated 6% of men with SUI 1 year after RP will seek an anti-incontinence procedure [5].

Sexual health and urinary function are paramount concerns relating to quality of life (QoL) following prostate cancer treatment [6]. SUI can affect the ability to function normally in society, and the cost of pads, diapers and other conservative therapies are an economic burden. Therefore, it follows that urinary outcomes after prostatectomy are one of the strongest predictors of patient health related QoL (HRQoL). Furthermore, HRQoL does not vary based on type of prostatectomy, open vs laparoscopic/robotic [7]. Return to urinary baseline function occurs in only 56% 1 year after RP [8]. Also problematic, 28–44% of sexually active patients after RP may also complain of climacturia defined as UI during sexual activity.

The pathophysiology of PPI is poorly understood. Theories include intrinsic sphincter deficiency and underactivity, neural impairment/injury, urethral support defects, and decreased membranous urethral length and venous sealing effect [9–12]. This has led to development of multiple conservative and surgical therapies attempting to either address the deficiency/injury or to replicate normal physiology.

Multiple treatment options exist for PPI, several conservative and several procedural. Absorbent pads often seen as first-line management does not treat incontinence but seeks to

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mask it. Clamps and condom catheters are cumbersome and may not be successful due to anatomic issues. Pelvic floor exercises (PFE) may reduce the time to continence after RP than men not undergoing PFE; however, persistent PPI 1-year after RP is poorly managed with PFE alone [13]. Surgical options offer the most success in treating persistent PPI.

Surgical treatments for PPI include the artificial urinary sphincter, male urethral slings, and endoscopic bulking agents. The artificial urinary sphincter has been the gold standard for the treatment of PPI, and can offer continence and satisfaction rates up to 90% [14, 15]. However, due to the cost of the device, patient reluctance to have or inability to manipulate a mechanical device, and fear of complication. Male urethral slings are an attractive alternative to the AUS since there is no need for activation of the device, operative time is less without the concern for mechanical breakdown, erosion, or need for removal and replacement. When given the option to choose between undergoing sling placement versus AUS placement, 9 out of ten men choose the sling over the AUS, and 1 in 4 still choose to undergo sling placement when an AUS is recommended.

The Virtue® male sling is a quadratic sling, made of 100% large-pore knitted monofilament polypropylene mesh, providing bidirectional *compression and elevation* of the bulbous urethra. It has two transobturator (TO) arms and two prepubic (PP) arms. The tensioning of all the arms simultaneously coupled with mesh fixation to the periosteum of the pubic ramus allow appropriate compression and elevation of the urethra. It has shown to have excellent short-term outcomes when managing mild to moderate PPI (range 79–100% using 0–1/pads per day) [1, 16]. Additionally, it is not uncommon for men with PPI to have concomitant erectile dysfunction and/or sexual dysfunction related to climacturia. The Virtue placement may be coupled with simultaneous penile implant placement without increased comorbidity and the mesh may also be fashioned as a “Mini-Jupette” to treat climacturia [17].

To date there has been no head-to-head comparison with the two-arm Advance Male Sling, or

the AUS (Boston Scientific, Minnetonka, MN); however, the quadratic sling offers several advantages. First it is placed over the bulbospongiosus muscle, which may be advantageous in men undergoing adjuvant radiation who are at higher risk of sling or AUS erosion. Second, the footprint of the quadratic sling mesh is larger than the two-arm sling, allowing for unique compression along its entire length. Third, the sling can be easily revised if UI recurs over time. The quadratic sling is fixated in place, thus has a predictable position, and once accessed via the prior perineal incision, it can be plicated with imbricating sutures to increase urethral compression. This revision technique has been reported as 63% of men improved and 44% were pad-free [18]. Surgeon preference and patient characteristics likely play the largest roles in choosing the chosen procedure/device. In this chapter, we will review the technical keys and perioperative considerations of quadratic male sling placement.

63.2 Patient Evaluation and Selection

63.2.1 Indications and Contraindications

Patient selection is very important: the Virtue quadratic male sling is best suited for men with mild to moderate SUI [1, 16]. The quadratic male sling has demonstrated safety and efficacy in the treatment of PPI. There is not data as of yet regarding use of the quadratic sling in men with post-TURP SUI, after repair of pelvic floor urethral distraction injury, or purely neurogenic causes of SUI. Men with documented incomplete bladder emptying, or untreated urethral or bladder neck obstruction should not undergo sling placement. Relative contraindications to quadratic sling placement are findings of poor bladder compliance and/or poor detrusor function with complete or near-complete bladder emptying. Prior history of irradiation to the pelvis is not a contraindication to sling placement since given the presence of the bulbospongiosus (BS) muscle between the sling and urethra. This key characteristic about

quadratic sling placement virtually mitigates the risk of sling erosion.

63.2.2 Pre-operative Assessment

A detailed history and focused physical exam is performed. This includes assessing the time of onset, duration, number of pads used, as well as any associated urinary voiding symptoms & neurologic complaints. A bladder diary is usually helpful adjunct to the voiding history. Prior urethral/BPH surgery, a history of urethral stricture, salvage prostatectomy, bladder neck reconstruction at the time of RP and a history of adjuvant radiation may also affect voiding and post-operative urinary function. The use of validated questionnaires can help characterize the leakage; however, are not necessary if an adequate voiding history is performed. Sling placement can be pursued at 1 year after RP when SUI will likely persist without surgical correction, and may be done prior if patients are experiencing significant distress from urinary function [19].

Charactering type of UI prior to surgical correction is tantamount to establishing patient expectations of success. Overactive bladder (OAB) may be present in 15.2–37.8% of men after RP [20]. Urinary at leakage at night, or leakage associated with urgency are typical complaints associated with urge urinary incontinence (UUI). Men with mixed UI, or both SUI and UUI, should be counseled that their leakage may persist after procedures to address SUI are performed. Additionally, OAB symptoms that were present prior to RP may return after an anti-incontinence procedure if their pre-operative OAB symptoms were volume related.

Pre-operative lower urinary tract evaluation via awake cystoscopy is recommended to assess for urethral patency and integrity of the membranous sphincter. Urethral obstruction from stricture related to prior catheterization/instrumentation may be present, as well as bladder neck contraction that may be present in up 3% of men after RALP [21, 22]. If urethral obstruction is present it should be managed, and the patient should be re-evaluated cystoscopically 3–6 months later to

assess for urethral patency prior to an anti-incontinence procedure [23]. The membranous sphincter can be visualized and assessed. The patient should be asked to voluntarily contract their membranous sphincter recognizing that poor or no coaptation may signify higher degrees of intrinsic sphincter deficiency and incontinence. In men having undergone prior adjuvant radiation, a visual assessment of the urethral mucosa should be made. Understandably, this is less important for quadratic sling placement since the sling is placed over the BS muscle making erosion a rare and currently unreported risk, yet it is important to remind the patient that he is at higher risk for revision/failure based on the radiation history alone.

Urodynamics as a part of routine pre-operative is optional; however, if the patient has a history of pelvic irradiation, Valsalva voiding, incomplete bladder emptying, or prior neurologic issue urodynamics should be pursued. If an AUS is chosen as the preferred procedure due to degree of incontinence, the need for preoperative urodynamic evaluation may not be necessary as urodynamic parameters do not predict adverse AUS outcomes [24]. Urodynamic evaluation is performed to differentiate the various causes of post-prostatectomy incontinence and rule out poor bladder compliance, high pressure detrusor overactivity during filling, and any bladder obstruction during the pressure flow study [25]. Urodynamic bladder capacity is also assessed, as most patients with severe incontinence have low functional capacity because of poor storage. Of note, *de novo* reduced bladder compliance may affect greater than 25% of patients up to 3 years after RRP [26]. Patients with poor compliance are not necessarily at risk for men undergoing AUS placement; however, proceeding with quadratic sling placement in these men should be done with caution. Detrusor hypocontractility can occur in up to 41% of men after RP, and may increase urinary retention rates after sling placement [27, 28]. In contrary to this, a contemporary series of 50 men with weak detrusor function characterized by bladder contractility index <100 or Valsalva voiding who underwent TO two-arm sling placement for PPI did not have any increase in urinary retention

between both groups when pre-operative bladder emptying was normal [29]. This would suggest TO male urinary slings are non-obstructive and safe in men with poor bladder contractility; however, the quadratic sling likely requires more pressure to void through after it is tensioned to an RLPP of 60 cm H2O. Until data is forthcoming, men with suspected poor detrusor function should be cautioned about possible persistent urinary retention after quadratic sling placement.

63.3 Adverse Outcomes and Complications

Bothersome issues that could arise postoperatively include urinary retention, scrotal/perineal numbness, scrotal/perineal pain, pelvic pain, wound issues, infection, persistent urinary incontinence. (Table 63.1) Possible complications that could arise, but have not been reported, include urethral perforation of sling into the urethra, permanent urinary retention requiring incision of sling, bladder injury from trocar, or neurovascular injury of structures within obturator foramen. There are no reports of permanent urinary retention requiring sling incision. The longest someone has had temporary urinary retention in the authors’ practices have been 2 weeks. After 1 week of post-operative urinary retention, consideration may be given to having

the patient perform deep squats in the clinic, which may help loosen the sling to regain the ability to void. Paresthesias and dyesthesias are not uncommon and can be caused by two possible mechanisms, either injury/compression of the superficial perineal nerve during the dissection lateral to the bulbospongiosus or compression by the sling on the perineal neurovascular bundle [30]. The alterations in sensation and pain are usually transient and those patients with protracted courses of recovery should be reassured as to the eventual dissipation of those symptoms within several weeks with the use of gabapentin and/or meloxicam.

63.4 Surgical Procedure

63.4.1 Positioning and Preparation

The patient is placed under general or spinal anesthesia. Preoperative antibiotics are given using vancomycin and gentamycin, and alternatives may be given due to patient allergy or hospital policy.

With the patient positioned in dorsal lithotomy, knees approximately shoulder-width apart and flexed no more than 90°. The thigh should be flexed to 90°, any less leads to more difficulty with sling component placement. The perineum, scrotum and pubic area are shaved. A standard surgical prep is performed. A 14 F Foley is placed, the bladder drained, and Foley is capped. An 0-0 silk may be placed through dependent scrotal skin and retracted superiorly.

63.4.2 Incision and Initial Exposure

A midline perineal raphe incision is planned, approximately 4–6 cm in length. The center of the incision should lie over where the catheter travels underneath the pubic symphysis at apex where the inferior pubic rami meet. It may also help novice implanters to mark the obturator foramen, insertion of the adductor longus tendon and inferior pubic rami as this offers visual cues for correct sling placement (Fig. 63.1).

Table 63.1 Complications associated with virtue sling placement

Quadratic sling placement	Complication	Rates [1, 16, 31, 32]
	Infection	0%
	Permanent urinary retention	0%
	Temporary urinary retention	3–4%
	Wound dehiscence	4%
	Erosion	0%
	Pelvic pain/numbness	12–30%
	Scrotal/perineal hematoma	1–3%
	UTI requiring readmission	1–2%

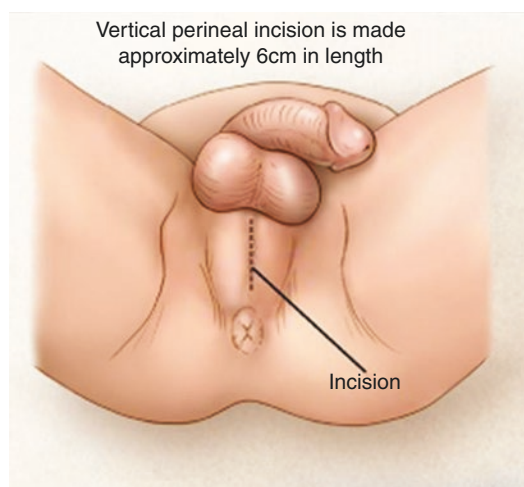


Fig. 63.1 Perineal raphe incision

A perineal incision is made in the midline, through Colles' fascia and through the perineal fat with electrocautery. The dissection should be carried deep at its posterior extent, if dissection is carried deep anteriorly then the scrotal compartment may be entered leading to obscured exposure. The deep extent of the dissection is easily found and characterized by contraction of the bulbospongiosus muscle. A fibrofatty plane exists over the muscle and this can easily be followed laterally to the inferior pubic rami which is the lateral extent of the dissection field. Expose the rami fully and carry the dissection inferiorly until the base of the bulbospongiosus (BS) muscle is visualized with the central tendon located in the posterior midline. The vessels to the BS muscle will be encountered on its posterolateral aspect and can be spared or taken with electrocautery. Next, a defect is created with electrocautery in the perineal fat from 4 to 8 o'clock for planned placement of the Alexis Wound Retractor (Applied Medical Systems, Rancho Santa Margarita, CA, USA) that is included in the Virtue mesh kit.

The Alexis retractor is removed and placed in irrigant. The green ring is compressed like a "taco," and inserted into the wound. It should lay flat and expand easily with appropriate exposure. If it does not, remove it and improve the exposure. Once the green ring is appropriately positioned,

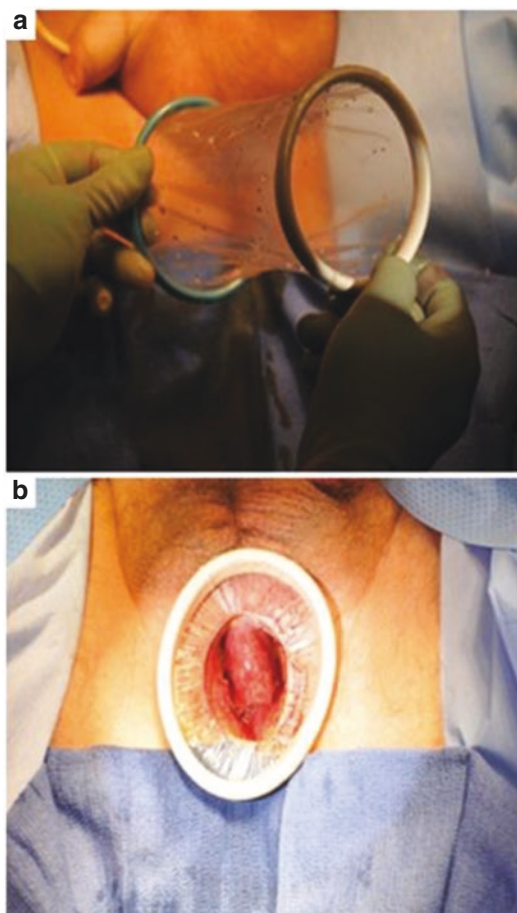


Fig. 63.2 (a) Alexis wound retractor. (b) Alexis in place with BS exposed, central tendon marked

the authors emphasize the white ring is folded *inward* until skin level is reached to provide maximum exposure (Fig. 63.2).

63.4.3 Mobilization of Bulbospongiosus

The central tendon should be easily located in the posterior midline. It should be cut sharply or with electrocautery in a semilunar fashion. Divide the central tendon and lateral muscular attachments until there is approximately 2 cm of mobility of the BS. Upward traction on the BS muscle either with toothed forceps or stay suture will aid in achieving appropriate BS mobility. Failure to mobilize the BS appropriately will result in poor

elevation of the bulbar urethral and in turn less urethral compression overall (Fig. 63.3).

63.4.4 J-Hook Passer

Once the BS is mobile then the sling can be placed with use of the J-hook retractor. The J hook passer is used to pass through the transobturator (TO) space in an inside-out fashion and from the prepubic (PP) skin into the wound from a top-down outside-in fashion. The benefit

of the Virtue J hook is that it is designed to be used for both sides using the surgeon's chosen dominant hand. The tip of the hook has two slots, a T- slot and an L- slot. We recommend using the T slot for small and normal size patients and the L- slot in more obese patients where the closer position of the suture to the passer tip allows for easier externalization at the skin level (Fig. 63.4).

The correct orientation of the sling is aided by the color of the plastic sheaths on each arm. The TO arms have a clear sheath and the PP arms have a blue sheath. An easy mnemonic to remember is that "blue (like the sky) lies north (Fig. 63.5)."

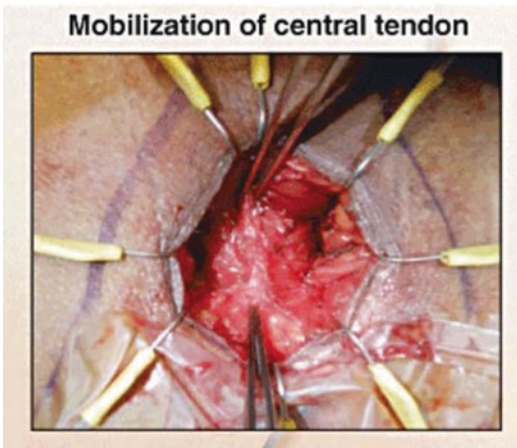


Fig. 63.3 BS prior to central tendon mobilization

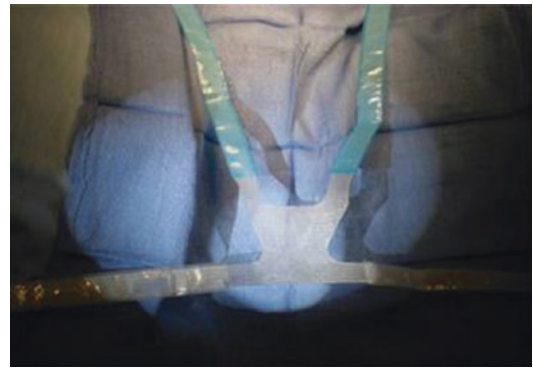


Fig. 63.5 Virtue sling (Prepubic arms – Blue plastic, Transobturator arms – Clear plastic)

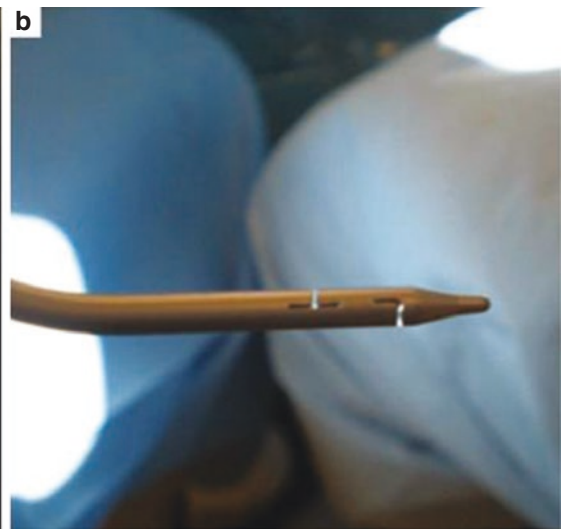
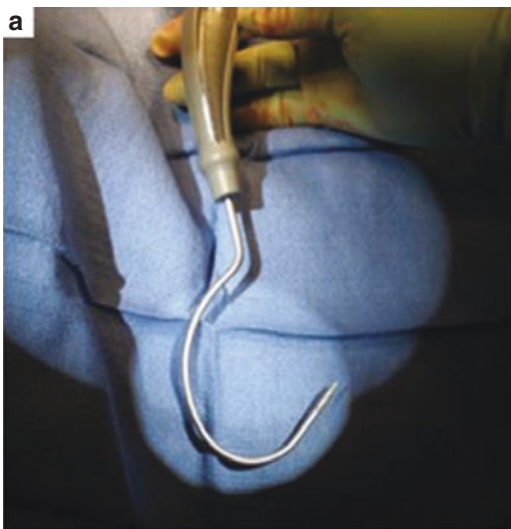


Fig. 63.4 J-Hook picture

63.4.5 Transobturator Arm Passage

The suture from the clear sheathed TO arm is placed within the T-slot so the knot of the suture sits securely within the hook. The knot should be in T-slot position towards the handle, if it is placed in the position towards the tip, the knot may slide out during passage. Remember, if the patient is large or obese strongly consider use of the L-slot to allow easier identification of the suture.

The TO arms are placed using an inside-out technique with the J hook passer. The TO pass is guided by hugging around the lower part of the inferior pubic rami approximately two finger breaths below the “apex” (the palpable point where the rami meet the symphysis). Placement of the tip of the passer must be positioned on entry “low” on the pubic rami to allow: (1) clearance of the pass through the foramen, (2) enough room to exert optimal urethral compression, and (3) mitigate contact with nerves that run higher along the inner rami. The correct position of the J-hook prior to entry into the TO foramen can be guided by the surgeon’s non-dominant hand index finger. The J-hook is held with the surgeon’s dominant hand with the tip of the passer parallel to the floor, and the handle pointing to the ipsilateral shoulder. Once the tip is past the pubic rami, a pop will be felt, and the dominant hand may be drop toward your body and then to the floor. The exit point of the passer is usually at the skin level approximately 2 fingerbreadths below the adductor longus tendon and 1–2 fingerbreadths lateral to the groin crease. This is an approximation of the exit point and in actuality it may be lower. Therefore, preplacing the stab incision prior the J-hook pass may lead to difficulty accommodating the trajectory of the tip to the exit site. Rather sharply incise skin on top and just medial where the passer tip tents the skin after the hook has been passed fully though the TO foramen. If the exit point is closer to the adductor longus tendon, repass the hook, otherwise post-operative discomfort and thigh pain may result. Once the tip is brought through the incision grab the suture knot, carefully remove it from the slot

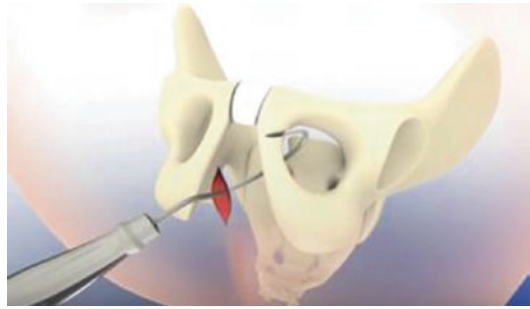


Fig. 63.6 Schematic of J-hook passing around pubic rami

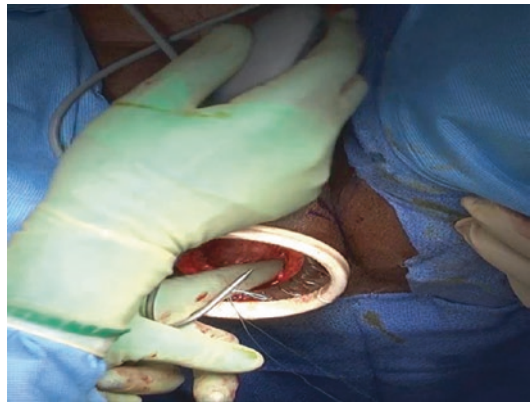


Fig. 63.7 Non dominant index finger guiding passer tip

and remove the passer in a rotational manner. The same steps are performed on the contralateral side. The TO arm sutures are then clamped (Figs. 63.6 and 63.7).

63.4.6 Prepubic Arm Passage

Next the PP arms will be placed. Lay the PP arms over the pubis and mark the incisions 2 cm above the pubic symphysis bilaterally. Place stab incision full thickness through skin and superficial fascia.

Pass the J hook passer, through the pubic stab incision, in front of the pubic bone (prepubic) not retropubic, and guide the needle out the perineal incision taking care to avoid the urethra in the midline. An index finger may be passed over the pubic bone on to the tip of the passer to help guide it lateral to the urethra and posterior to the

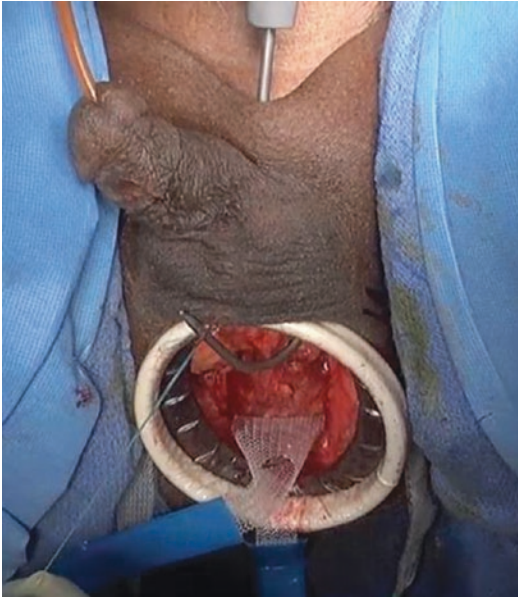


Fig. 63.8 Tip of passer through wound

spermatic cord. Over dissection of this plane can lead to scrotal numbness as the genital branch of the genitofemoral nerve may be in this area. Once the tip is passed into the wound, attach the suture loop of the prepubic arm into the T-slot closest to the tip of the passer and pull up thru the incision. Repeat these steps on the contralateral side. Clamp the PP sutures (Fig. 63.8).

63.4.7 Tensioning of Mesh

Prior to full tensioning of the mesh, apply gentle tension on the TO arms to seat it posteriorly on the BS muscle. Confirm the mesh sits evenly and flat on the BS muscle. If there is a significant amount of laxity in middle of the mesh, consider repassing the TO arms lower on the pubic rami.

The TO arms are then fully tensioned by pulling the clamp holding the TO sutures towards your body. This step should always occur prior to tensioning the PP arms. Next, the PP arms are tensioned by pulling the clamp towards the head, not towards the ceiling, with continuous tension on the TO arms.

Tensioning of the PP arms prior to the TO arms can lead to distal migration of the sling.

Tensioning the PP arms towards the ceiling, instead of towards the head, can lift the sling off the urethra leading to less optimal urethral compression.

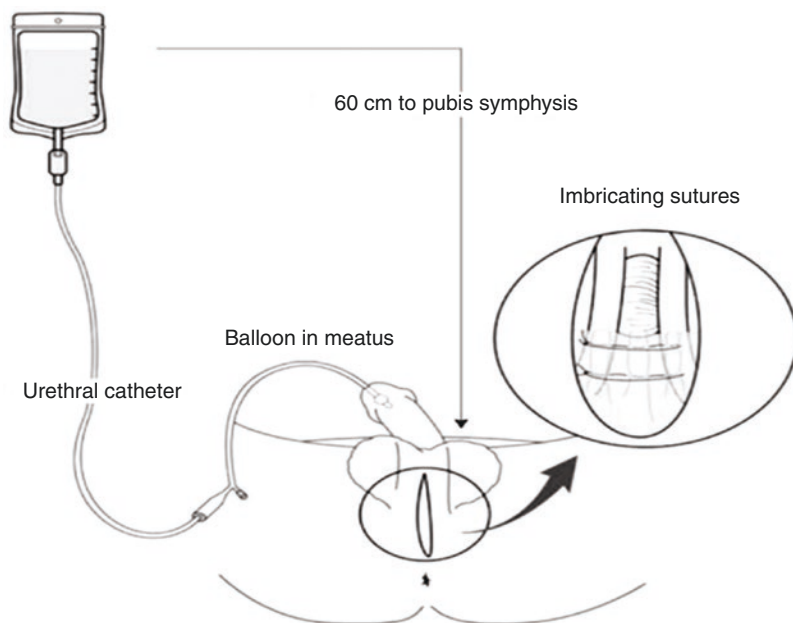
63.4.8 Retrograde Leak Point Pressure

Retrograde leak point pressures (RLPP) should be obtained at this point to confirm optimal urethral compression. This step is recommended to all, especially novice implanters. This step serves an easy to perform confirmatory test of appropriate sling tensioning. This step has been previously described and developed by Comiter et al. [33]

A Foley balloon is placed within the fossa navicularis and filled with 2–3 cc of water. A bag of saline or water is hung, with the water line 60 cm above the pubis assuming the patient is in a flat position. Irrigant tubing is connected to the Foley and the flow of fluid is initiated. When the fluid in the drip chamber of the TUR tubing ceases to drip, a *RLPP of 60 cm H₂O has been reached* and optimal compression has been achieved. It is critical that the mesh be fixated in this position to maintain the optimal urethral lift and compression by the sling. Using a heavy clamp for each PP arm anchored under tension against the patient's skin is an effective way to maintain the tension (Fig. 63.9).

Several factors may lead to not achieving the desired RLPP. First, the most common reason is not tensioning appropriately. Following the previously aforementioned steps to achieve maximal tension are paramount. Second, it takes some time for the urethra distal to the sling to fill with irrigant. Continually apply tension and manual pressure to the base of the sling on the BS and wait up to 20 seconds before choosing to do another maneuver. Third, the sling is mispositioned. This is usually not the case if the previous steps have been followed; however, if the sling is not sitting flat on the muscle then the TO arms should be repassed. Lastly, in a urethra that has been instrumented previously, or in men with history of irradiation and relatively fixed urethra

Fig. 63.9 Schematic representation of retrograde leak point pressure testing



may develop. In this situation, the urethra may be difficult to compress to get the desired RLPP. In this situation, one may consider corset sutures after PP arm fixation. In the authors experience not obtaining a RLPP of greater than 60 cm H₂O is extremely rare.

63.4.9 Mesh Fixation

This is the *most critical portion of the procedure* to maintain the urethral compression of the mesh. It is the authors' opinion that the efficacy of the quadratic male sling rests on the quality of this fixation. The mesh is tensioned to the surface of the pubic bone and with figure of 8 sutures on each side. Two fixation sutures must be placed on each side. The aim is to minimize the chance of the sling loosening, as the fixation of the anterior portion of the sling is critical to success. The location of the fixation sutures should be at the junction between the body of the sling and the PP arms of the sling. We recommend using a #1 polypropylene suture (Covidien Surgipro #1 HGS-22 tapered needle) or a 0 polypropylene suture (Ethicon Prolene 0 MO-6 needle). Fixation sutures should be carefully placed making sure the initial figure of 8 throw is

securely along the periosteum with the second throw incorporating just the mesh more medially from the first throw at the level of the leading edge of the mesh, allowing the sling to stretch over the BS. Repeat on the contralateral side. Pulling on the PP arms after fixation allows assessment of appropriate sling fixation i.e. the sling should not move. The irrigant flow should be restarted or continued through the fixation, making sure that drip in the fluid chamber has ceased. If the drip has significantly slowed but not stopped a second set of fixation sutures may be placed. Several rows of corset sutures may also be placed through the body of the sling to further tighten the sling if the RLPP of 60 cm H₂O is not reached (Fig. 63.10).

63.4.10 Tunneling of Transobturator Arms

Replace the 14F Foley catheter and ensure it passes past the sling. Resistance being felt as the catheter passes the sling is commonplace and may be ameliorated by injecting lidocaine jelly into the urethra and/or using a Coude tip catheter. If it still cannot pass, which would be rare, then cut a suture to release slight tension to confirm

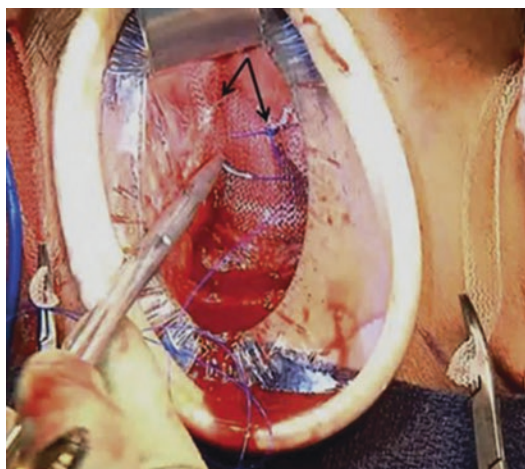


Fig. 63.10 Placement of fixation sutures

passage. Replace that suture once a Foley is placed. Cut the PP arms at the skin level. For the TO arms, use a Tonsil or Vanderbilt clamp through the perineal incision in the subcutaneous space and tunnel to the mesh at the exit site. Grasp the mesh arm with the end of the tonsil clamp and pull back through the new subcutaneous plane to the perineal incision. Trim the mesh inside the perineal incision. Repeat these steps on contralateral side. Some implanters recommend fixating the TO arms to the base or leading edge of the mesh. If this is performed the TO arms should not be fixated on tension as they could loosen the sling by lifting the base of the sling off the BS (Fig. 63.11).

It is important to place local anesthetic throughout the four male sling arms and along the path of the J-hook passer. Long acting liposomal bupivacaine (Exparel) may provide 72 hours of pain relief has been helpful in improving postoperative pain control. A 1% ropivacaine (20 mL)/dexamethasone 8 mg mix is a cheaper alternative; however, will likely have a shorter duration of effect. Anesthesia as well may administer 30 mg Toradol at time of closure.

63.4.11 Closure

We complete a multi-layer closure of the perineal incision using running 3-0 chromic approximat-

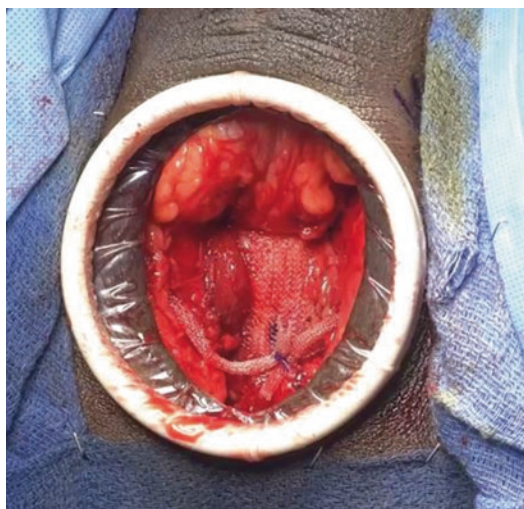


Fig. 63.11 The tunneled TO arms anchored back to mesh off tension

ing the deep perineal tissue and vicryl undyed suture for approximating Colles fascia. Skin may be closed by a running horizontal mattress or subcuticular fashion. Skin glue may be used for all the incisions and should be all that is necessary for the pubic and TO stab incisions. A dressing of fluffs and scrotal support is placed prior to waking the patient up from anesthesia.

63.5 Postoperative Management

The Virtue Quadratic Male Sling is an outpatient surgery. Patients are sent home with ice pack and 1 week of Cephalexin as well as tramadol for pain control. Patients are advised not to have the knee go past the level of the hip, or to squat down for any reason until 6 weeks post operatively. This may cause early loosening of the mesh. Twisting motions, such as a golf swing, are also not recommended for that time period. We remove the Foley catheter in our clinic on post-operative day 1 and check the wound at 2 weeks, with a 6-week follow-up for symptom assessment. It is not uncommon for a failed trial of voiding to occur on the day following surgery. There are no reported rates of sustained retention following quadratic sling placement.

63.6 Revision of Sling

For men who have a recurrence of their leakage, after initial improvement, or whose leakage control does not meet their expectation, a revision procedure to further tighten the quadratic sling may be performed [19]. This outpatient procedure may be pursued at the earliest 6 months after their initial procedure to allow mesh integration into the native tissue. This is performed via the same incision and is less invasive than the initial procedure. This is an appealing option to patients who would rather not proceed to AUS placement; however, does not preclude AUS placement in the future if the patient continues to suffer from urinary incontinence.

Prior to proceeding with urinary sling revision, it is important to clarify what type of incontinence exists. This can be done easily in the office with a detailed voiding history. For men, who have had recurrence of or *de novo* OAB, they may experience urge urinary incontinence which has a different management schema than SUI. A revision procedure for persistent or recurrence of incontinence best characterized as UUI is not going to be beneficial as one would expect.

A revision procedure is carried out through the prior perineal incision using similar steps for wound exposure. A catheter should be placed prior to the dissection. The dissection is carried deep until the mesh is encountered. The mesh is exposed on its anterior aspect with the “leading

edge,” of the mesh being the critical portion requiring exposure. The dissection should be carried lateral until the fixation sutures are visualized. An inverted triangle of mesh is exposed with the base of the triangle being the “leading edge” [34]. The extra small Alexis retractor is placed into the wound for retraction. The aim of the revision procedure is to tighten the sling using the slings in growth and fixation into the native tissue by imbricating it over the urethra. 3–4 rows of corset 0 polypropylene sutures are placed in a vertical mattress fashion at 1 cm intervals. (see Fig. 63.12) The first row should be 1 cm posterior to the leading edge so as not to create an obstructive band with the mesh. Retrograde leak point pressures should be obtained as the most distal corset suture is tied down utilizing a surgeon’s knot. The other knots are then tied down in a similar fashion taking care to apply the appropriate tension to maintain the RLPP >60 cm H₂O (Fig. 63.12).

It is also critical to recognize the position and placement of the mesh as it is exposed. Sometimes the fixation sutures may have failed to fixate to the periosteum leading to an early recurrence or persistence of incontinence. This may occur with poorly placed sutures, poor tissue strength or squatting, lifting, or high stepping maneuvers in the early post-operative period. We find it beneficial to re-fixate the junction of the PP arm and body of mesh to the periosteum if this is encountered. Doing this prior to corset suture placement

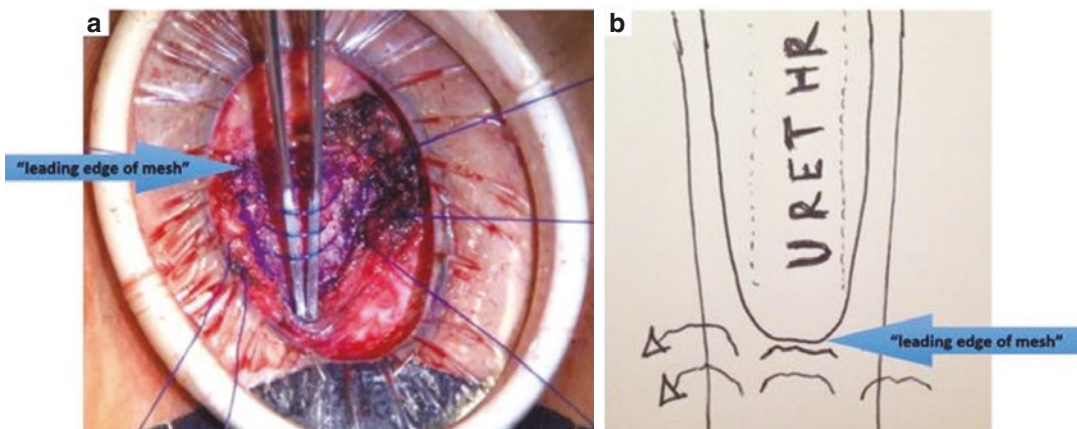


Fig. 63.12 Sling revision: imbricating plication sutures are placed superficially through the mesh material

allows the entire footprint of the mesh to exert equal compressive force over the urethra.

Once the mesh has been re-fixated and/or pliated as well as the RLPP of 60 cm H2O achieved the wound may be closed in a similar fashion described previously. A Foley catheter is placed prior to awaking from anesthesia. The patient again is advised to restrict activity and motions that could possibly loosen the sling. The Foley is removed post-operative day #1.

Masterson et al., in a single surgeon cohort, found that this revision technique performed after quadratic sling failure led to 44% success (7 of 16 patients) [18]. Success was defined as a daily pad count of 0 after the procedure. Three of 16 men (19%) showed improvement but still required pads. Another 3 men (19%) had no improvement. Three men later underwent uncomplicated AUS placement due to inadequate improvement.

63.7 Discussion

Approximately, 165,000 men are diagnosed with prostate cancer in the U.S. each year, with 50% ultimately choosing surgery as their treatment of choice [35]. Of the men who have persistent PPI after their prostatectomy an estimated 4% of prostatectomy patients will opt for surgical management to treat their incontinence within the first 3 years after their cancer surgery [36]. AUS has remained the mainstay and most commonly used method for the correction of PPI. However, AUS carries a well-known risk for reoperation, with infection rates of 5–6%, erosion rates of 6–8%, and mechanical failure in 6–23% of cases in up to 13 years of follow-up [37–39]. The male sling arose out of necessity for a less invasive, lower risk procedure than the AUS, especially in men with less severe incontinence and who may not want a mechanical device.

Multiple slings have been developed for the treatment of PPI. The InVance (American Medical Systems, Minnetonka, MN, USA) bone anchored sling directly compressed the bulbar urethra against the genitourinary diaphragm utilized bone anchored screws to maintain this

compression. Success of decreasing urinary leakage and pad use was 60–85%; however, use was largely abandoned due to high risk of infection, osseous complications, and technical challenges of bone screw placement. The AdVance two-arm transobturator sling was introduced in 2004, to permit a minimally invasive approach via a straightforward outside-in TO placement. This device provides only minimal compression of the bulbar urethra; however, its mechanism of action relies on relocating the bulbar urethra more proximal. It is hypothesized the laxity of the posterior support mechanism of the urethra after prostate removal leads to poor coaptation of the urethral sphincter complex [40]. The relocation of the proximal urethra by this retroluminal sling can lead to potential restoration of the pre-prostatectomy urethral configuration. Although, the TO sling has been shown to be effective at short term follow-up in the management of mild to moderate SUI, failure rates have ranged from 20% to 45% [41].

The quadratic male sling utilizes and combines the compression and elevation/relocation action of the two prior sling systems to obtain improvements in urinary function. This concept has been shown by intraoperative retrograde leak point urethral pressures increasing by separate tensioning of the PP and TO arms [33]. The design of the Virtue quadratic male sling overcomes the potential drawbacks of other male slings through the absence of bone screws, and a combination of horizontal urethral compression by the transobturator arms, in addition to the vertical support of prepubic arms allowing a longer zone of urethral compression.

The Virtue sling has been successful at short- and mid-term follow-up at managing PPI and improving quality of life in the sling fixation era. (Table 63.2) Study populations not utilizing have fixation of the mesh to the pubic rami periosteum have failed to provide successful outcomes or have had early failure in maintaining continence in the short-term [16, 31]. Comiter et al., in the first multi-institutional trial compared groups undergoing sling without fixation to those who did. In the initial non-fixation cohort, subjective and objective successes were

Table 63.2 Results of quadratic sling procedure in males with stress urinary incontinence

Studies	# men	Median follow-up (mo)	Fixation	RLPP	Postoperative success/pads per day (PPD)	Notes
Comiter et al. [16]	98	12	No	Yes (>60 cm H20)	Mild incontinence: 37% Moderate incontinence: 57.9% Severe incontinence: 44%	Success reported as >50% decrease in pad weight
	31	12	Yes	Yes (>60 cm H20)	Mild incontinence: 80% Moderate incontinence: 83% Severe incontinence: 71.4%	No change in perineal pain or paresthesias between fixation and no fixation group
McCall et al. [31]	32	55	Yes (not to periosteum)	Not indicated	Median PPD: 2 (1–2.5)	Underwent 3-, 4-, 5- arm fixation with plication. High rate of AEs – 44% urinary retention, 22% sling removed due to pain, 20% underwent AUS placement after sling failure
Ferro et al. [1]	29	14.5	Yes	Not indicated	Median PPD: 0(0–1) 24 hr pad weight: pre 128.6+/- 71.9 g post 2.6 +/- 5.4 g	No men with severe incontinence included
Sourial et al. [32]	18	22	Yes	No (tensioning under cystoscopic vision)	Overall: 39% Median PPD: 3 (1–5)	Success defined as 0–1 ppd, or > 50% daily pad reduction
	30	22	Yes	Yes (final RLPP after fixation was 40 cm h20 on average)	Overall: 70% Median PPD: 1 (0–1)	

achieved in 41.9% at 12 months. Median pad weight reduction was 51.1% at 12 months and varied with the degree of baseline leakage. In the fixation cohort, subjective and objective successes were 70.9% and 79.2%, median pad weight reduction was 88.3% at 12 months, and efficacy was similar regardless of baseline incontinence. McCall et al. followed with a single surgeon cohort with longer-term median follow-up of 55 months. Success was poor, complications and reoperation rates were high leading to the abandoning future use of the sling. 68% of patients were considered failures, 44% had urinary retention and 20% underwent AUS placement. Fixation was used; however, it was not the current protocol utilized today fixat-

ing the mesh to the periosteum of the pubic rami. In this study multiple arms were fixated to the obturator foramen or abdominal wall depending on the respective arm. Also, it is not clear what method to assess adequate tensioning was used. These issues may have some effect on the overall poor outcomes experienced. Ferro et al. reported their outcomes in 29 patients with the recommended fixation protocol performed. No indication of tensioning assessment was given; although, it was reported that “maximal” tension was applied prior to fixation. In their series, 82.7% of patients used no pads per day and 17.3% used one pad per day at 12 months after placement of the sling, an excellent short-term outcome.

As stated previously, RLPP assessment remains an important way to assess that the appropriate tension the sling needs to compress the urethra maximally. Sourial et al. compared patients undergoing sling placement based on sling tensioning technique. In their initial series (Group 1) they fixated the sling after the urethra was seen to coapt on cystoscopy. In the next group (Group 2), they utilized a RLPP of $>60\text{cmH}_2\text{O}$ prior to fixation. Success was defined as “cured” being no pad used, and “improved” being use of 0–1 pad per day, or $>50\%$ decrease in pad use. Patients in Group 1 were cured or improved of their PPI, compared to 21 (70%) patients in Group 2 ($p = 0.03$). Even after adjusting for baseline PPI, men in Group 2 were more likely to have demonstrated an improvement or a cure of their PPI than men in Group 1 (OR 3.5; 95% CI 1.02–12.1). Postoperative median (IQR) ppd. for Group 1 vs. Group 2 was 1.5 (0–3) vs. 0 (0–1) ($p = 0.002$); and three (1–5) vs. one (0–1) ($p = 0.004$) at the 2-month and last follow-up visit, respectively. Interestingly, in Group 2 they found that after the sling was fixated, the average RLPP was 45 cm H₂O. They concluded that the 60 cm H₂O RLPP measurement during tensioning does not reflect the “true” measure of urethral compression. Nevertheless, the RLPP tensioned group fared better than visual tensioning. This information highlights the tension needed to achieve success may be greater than one initially thinks. Therefore, it is imperative that novice implanters or those experiencing less than optimal outcomes utilize this confirmatory test to objectively confirm optimal placement.

The current body of literature regarding Virtue sling placement unfortunately suffers from unequal patient cohorts, different operative protocols, and different measures of success. This is ubiquitous among other sling and AUS cohorts. Large multi-institutional trials with longer follow-up and preferably randomization will lead to answers to many existing questions. Nevertheless, Virtue remains a superior product that has definite benefits that would aid in managing PPI, whilst also allowing for easy placement of an AUS should failure occur.

63.8 Conclusion

The Virtue Quadratic Male Sling with fixation and intraoperative RLPP monitoring is a safe and efficacious treatment for post-prostatectomy incontinence in patients with mild to even severe symptoms as evidenced by both subjective (patient satisfaction) and objective measures. Furthermore, the sling can be revised in the event of refractory or worsening leakage and does not preclude placement of an AUS should one be needed. Ultimately, this allows the patient and the surgeon more options in the treatment of a debilitating condition.

Key Summary Points

- Placement of Virtue Quadratic Male Sling is a treatment option for men suffering from stress urinary incontinence
- The quadratic sling is 4-arm polypropylene mesh placed in a minimally invasive fashion through a perineal incision
- It is the only male urethral sling that both relocates the proximal urethra via elevation, and significantly compresses the urethra simultaneously
- The sling is placed directly on the bulbospongiosus muscle, virtually negating the chance of erosion, and making it an attractive option for men with prior pelvic irradiation
- Correct placement of the sling, incorporates sling fixation to the pubic rami periosteum and retrograde leak point measurement $>60\text{ cm H}_2\text{O}$ to ensure adequate sling tension and urethral compression
- In cases of persistent or recurrence of incontinence it may be revised via mesh plication with good success and minimal comorbidity
- Quadratic sling placement does not preclude or complicate future AUS placement should the need arise

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Treatment of Male Stress Urinary Incontinence: ATOMS System

64

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64.1 Introduction

Despite technical advantages in prostate cancer surgery, stress urinary incontinence (SUI) continues to be the most distressful complication after radical prostatectomy as it severely impacts patients' quality of life and well-being [1, 2]. The reported incidence of distressful SUI after prostatectomy is around 10% of the patients intervened but, depending on the severity, it ranges from 4% to 40%. That gives an idea on the magnitude of this sequela that may be more dependent on the surgical experience than on the elected surgical approach [3–5].

SUI tends to improve until 12–18 months after surgery but also late functional recovery within 3 years is possible [6]. Risk factors include patient age, bladder dysfunction, salvage prostatectomy after radiotherapy or previous transurethral resec-

tion of the prostate (TURP) and advanced stage of disease. Pathophysiology of SIU after radical prostatectomy includes dislocation of the posterior urethra, together with fibrotic scar in the urethral anastomosis that contributes to urethral stiffness and makes the sphincter dysfunctional [7]. Approximately 2% of patients undergoing TURP or other surgeries for benign prostate hyperplasia (Holmium enucleation or simple prostatectomy) also develop SUI and this estimate is much higher when TURP is performed after external radiotherapy or brachytherapy [8, 9]. The pathophysiology of SUI in these cases stands on damage of the external urethral sphincter generated during resection by constant pressure in the resectoscope channel.

Artificial urinary sphincter (AUS) has been classically considered the most efficacious method to treat moderate-to-severe SUI, regardless the high complication and revision rates [10, 11]. Despite its use for more than three decades, quality of evidence supporting AUS in non-neurogenic male patients with SUI is low and mainly based on cohort analysis [12]. Male slings have gained popularity to treat mild-to-moderate SUI due to ease of surgery, good functional results and low complication rates [13]. Repositioning of descended dorsal support structures of the sphincter that increase functional length of membranous urethra can be achieved by retrourethral transobturator slings [14]. Adjustable bulbourethral male slings reveal very promising results [14, 15].

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64.2 The Atoms Concept

ATOMS is the acronym of Adjustable Transobturator Male System, a self-anchoring transobturator device produced by Agency for Medical Innovations GmbH, Austria. The device is composed of a polypropylene mesh for outside-in transobturator passage and a central silicone inflatable cushion connected to the port that is subcutaneously placed. Once implanted perioperative filling through the access port compresses bulbar urethra ventrally and this compression can be postoperatively increased by the simple injection of additional sterile liquid through the subcutaneous port placed in the scrotum, without need of surgical intervention, anesthesia or fluoroscopic guidance. This easiness for postoperative adjustment makes this device the most comfortable adjustable sling both for patients and doctors, and opens a new perspective of treatment for SIU of any severity, especially for patients with mild-to-moderate SUI. Experience regarding the efficacy of ATOMS in severe male stress incontinence is accumulating, thus confirming AUS is not the only goldstandard in such scenario [16–35]. In fact, ATOMS can be the best option in patients with limited dexterity or cognitive impairment and SUI of any degree as patients urinate without need of manipulating the device. However, there are still great uncertainties concerning optimal patient selection because comparative studies between ATOMS and other devices (AUS and fixed male slings), which could help physicians to select ideal patients for each treatment, are unfortunately lacking.

In the meantime, the best indications for the adjustable male sling system ATOMS seem to be mild-to-moderate SUI, especially cases in which retrobulbar sling is not effective. Those are cases in which a coaptive zone longer than 1 cm is not confirmed during urethroscopic repositioning test or patient that have received previous radiotherapy [15]. However, use of ATOMS is increasing as this alternative also covers the optimum indication of retrourethral slings and can also be a good alternative for severe SUI without need of manual control by the patient [29, 30, 32].

However, best results can be anticipated for not severe SUI and non-irradiated patients [32].

The ATOMS device is now being used for 10 years and its design has slightly evolved in time. Although the main components, the transobturator mesh and the silicone cushion remain unchanged, the design of the port filling system has progressed from a first-generation inguinal port (IP) marketed in 2008 to a second-generation scrotal port (SP) launched in 2013 and a third-generation silicone covered scrotal port (SSP) released in 2014. This evolution implies several important advantages, such as to place the device through a single perineal incision, to avoid titanium reaction thanks to the silicone cover of the SSP and to shorten operative time due to pre-attachment of the port. Also, postoperative pain is reduced with a single incision and infection risk is diminished. Possibly the durability of the ATOMS device may also be higher for SSP design [33].

ATOMS can be used in irradiated patients, and this is also a very interesting advantage over other retrobulbar systems such as Advance® or male readjustable sling (MRS®). Also, ATOMS can be used in patients with former urethroplasty or previous healed urethral erosion due to male sling or complicated AUS [35]. Patients with blocked perineum (e.g., previously repaired urorectal fistula) can receive ATOMS as well as this device is an alternative to transcorporeal AUS in this group of patients. The results of ATOMS for SUI after TURp seem to give very similar results to ATOMS after radical prostatectomy [34].

64.3 Preoperative Evaluation

Candidates for ATOMS placement should undergo anamnesis and physical examination to confirm the patient is a good candidate for surgical correction of SUI and also to adequately decide ATOMS is the appropriate device. Clinical history should include the etiology of SUI, severity of incontinence, prior therapies, history of urethral and or bladder disease, and radiation therapy. Lower urinary tract symptoms

other than incontinence, active urinary infection and high residual urine volume should be ruled out. Untreated urethral stricture, bladder neck contracture, neurogenic dysfunction and hypoactive bladder are contraindications for ATOMS placement. Urodynamic study is not mandatory but should be considered in cases with high residual volume and/or severe detrusor overactivity.

Physical examination is crucial to observe leakage on coughing and both pad-count and pad-test (average of several days) give an idea of the magnitude of incontinence. Post-void residual volume measurement excludes overflow retention and cystoscopy allows the identification of strictures. Urethral repositioning test can be performed but physical examination under cough without and with perineal compression (male Bonney test) gives a better idea to consider ATOMS will allow good postoperative results as urethral compression reproduces the inflation of the device cushion. Mild-to-moderate incontinence (<5 pads per day) will allow better results, but pad-test is not a limit for indication of ATOMS as patients with 6 or more pads per day may also achieve dryness if they are correctly selected. The question whether patients reach the toilet in the morning gives also a clue that the sphincteric damage is not total and also helps to select patients for ATOMS. Also confirmation that urine loss during Valsalva is prevented by press-

ing bulbar urethra with a sponge on stick is also very helpful to select the ideal patient for ATOMS.

64.4 Surgical Technique

Implantation is performed under dual antibiotic treatment consisting of one single-shot i.v. 240 mg gentamicin 2 hours before induction and three times a day oral 500/125 mg amoxicillin/clavulanic acid for 1 week postoperatively. The surgical procedure is performed with the patient under spinal anesthesia in the lithotomy position, with a 14-Fr Foley catheter inserted for intraoperative and postoperative bladder drainage. A medial vertical perineal incision is performed with blunt dissection of Colles fascia and bulbospongiosum muscle exposed. The fossa ischiorectalis is dissected on both sides with exposure of ischiocavernosus muscles. The obturator fossa is palpated by identification of the ischiopubic bone and the mesh arms are introduced through the obturator foramen using helical tunnelers in an outside-in technique (Fig. 64.1). The tunneler is moved around the ramus inferior of the ossis pubis in helical fashion by means of a rotary movement using the index finger of the contralateral hand to identify the tip of the tunneler in the fossa ischiorectalis and guide it out of the wound.

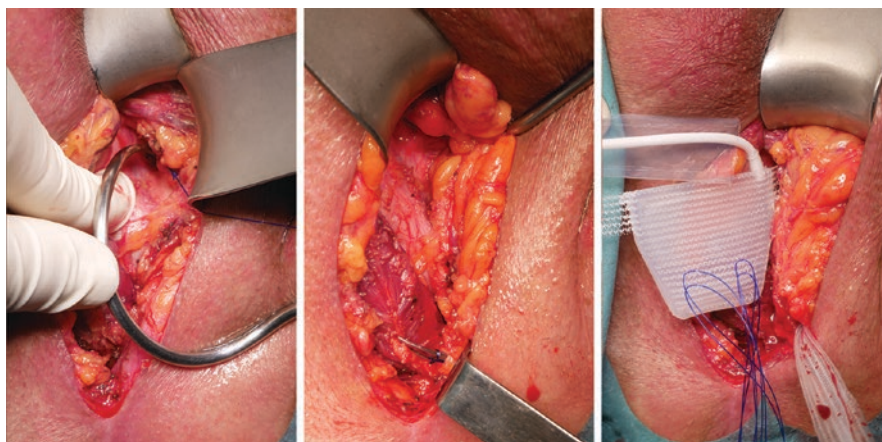


Fig. 64.1 Transobturator passage of the mesh using helical tunneler leads to central position of the cushion to ventrally compress the urethra

The tunneler is then pulled back and the same maneuver is performed in the other side. Then the implant is brought into midline position by pulling both sling arms. After this maneuver the cushion gently compresses the urethra ventrally. Once the covers of the sling arms are removed the mesh arms are secured to the central cushion under tension on both sides using the integrated attachment sutures, thus establishing a 4-point fixation to the obturator foramen and bone on each side in the male pelvis that avoids dislocation of the cushion. The excess mesh arms are cut (Fig. 64.2). Washing with 240 mg gentamicin solution in 500 mL is performed throughout the procedure.

Intraoperative filling is performed by venting the implant using a non-piercing needle with eyes separated from the tip to inflate saline solution into and outside the port, thus leaving no gas into the system. Later filling of the cushion is performed with saline solution in a regular atmosphere pressure depending on the tightness of the suturing, usually 8 mL. Initial overfilling of the system can be incorporated in correlation with the severity of SUI.

The SSP cover is removed before placing it in the scrotum without tension and preventing kinking at a readily accessible location for late post-operative percutaneous access (Fig. 64.3). A drain is not needed as oozing ceases once the

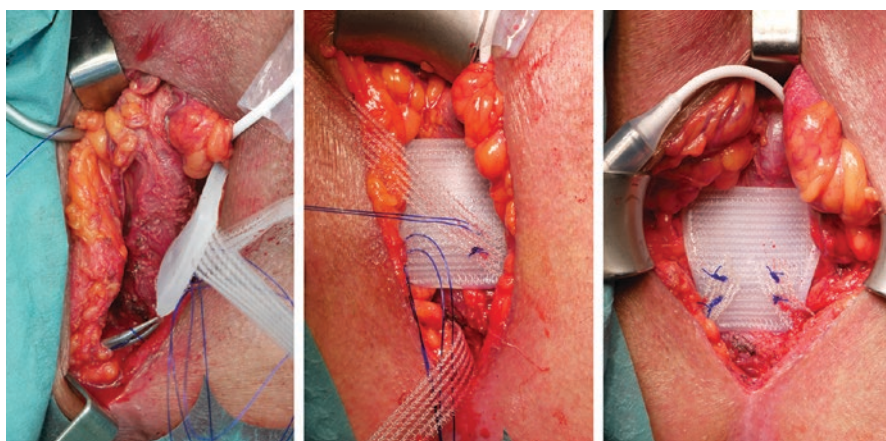


Fig. 64.2 The mesh arms are secured to the central cushion under tension on both sides using the integrated attachment sutures

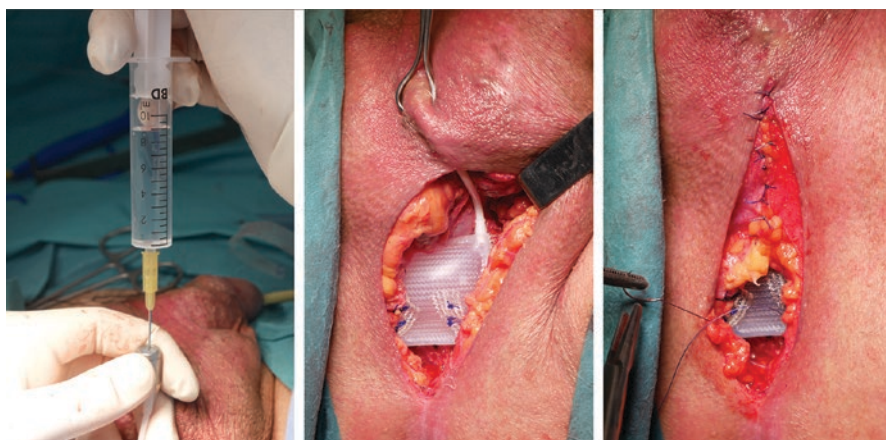


Fig. 64.3 After venting of the system through the port the cushion is filled with saline solution, the port is placed in the scrotum and the wound is closed

cushion is inflated. Perineal wound is closed taking care not to puncture the cushion. The patients are generally discharged overnight with Foley catheter maintained for a few days until outpatient visit to prevent urinary retention.

64.5 Perioperative Considerations

Perineal pain and numbness are not rare after hospital discharge and should be prevented or treated with anti-inflammatories and/or analgesics. Very exceptionally pain lasts for 3 months. Postoperative adjustment is performed if dryness is not reached by direct percutaneous injection of 2–3 mL saline serum or sterile water with a non-ionic contrast agent in the port 3–4 weeks after surgery, using again a non-piercing port needle. Subsequent additional filling with smaller volumes to minimize the risk of urinary retention can be performed every 3 weeks until continence is reached or maximum total filling of the system (no more than 25 mL recommended). In the Iberian multicenter study 31.6% of the patients needed no postoperative adjustment and the mean number of fillings was 1.4 ± 1.9 (range 0–9). More volume inside the system is not related to higher dryness rate and the decision on how much filling should be individualized for each patient according to his needs and expectations [32]. Solution can be removed if the patient has difficulty to void, what very rarely happens. Also, if the patient needs a cystoscopy or any endoscopic manipulation during follow-up the system can be emptied to facilitate the procedure. Patients are evaluated postoperatively with post-void residual and daily pad-test and thereafter in consonance with the follow-up of prostate cancer.

64.6 Outcomes

ATOMS has been used now for a decade and outcomes with the device have been reported to date in 20 publications, most single center retrospective studies (Table 64.1). However, some groups have pooled their experiences thus providing real

world experience and also prospective data. Unfortunately, no comparative study with other devices (AUS or non-adjustable sling) has been published to date. Dryness rate and improvement rate tend to be the most commonly reported outcomes, together with daily pad-count change (baseline and after adjustment). Some articles also detail daily pad-test change and satisfaction with the device. Only two large series have studied durability of the device [28, 32]. A systematic review and meta-analysis of published literature with ATOMS has been recently undertaken [36].

The concept of a self-anchoring transobturator male sling to treat male SUI based on anatomical findings in a cadaveric study was originally developed by Bauer et al. in 2005 [37] and was the basis for ATOMS development and marketing in 2008. Bauer and Brossner reported the first clinical description of the device with emphasis on the surgical technique in 2011 [16] and precise data of a clinical experience with ATOMS was originally reported in 2012 [17] as first or second line treatment for mild to moderate male SUI after RP, even after external radiation. At a mean 16.9 months follow-up the objective success rate reported was 84.2% (60.5% became dry and 23.7% improved) despite a high proportion of cases with severe (>5 pads/day) incontinence (57.9%), secondary treatments (28.9%) or previous radiation (44.7%). That same year the first prospective non-randomized multi-center study also reported excellent results with 92% success rate (63% became dry and 29% improved) at a mean 17.8 months follow-up, also with a very high proportion of severe incontinence (70.7%), previous surgeries (34.3%) or previous radiotherapy (31.3%) [19]. An update of this series was published also in German language [18].

Later other individual center studies were published with variable results. A small series of patients with mild (1–2 pads/day) incontinence achieved 92.3% total dryness rate at 16 months [21]. A very heterogeneous series with 30-months follow-up only achieved 38.9% cure, but with significant reduction in ICIQ-SF score and in mean pad-count/day (from 8.3 to 2.7). They had 30.6% explant rate but surprisingly high patient satisfaction [20]. Another prospective study of

Table 64.1 Clinical studies with the adjustable transobroturator male system (ATOMS)

Author year (References)	N	Definition of dryness	Dry rate (%)	Improved rate (%)	Number of adjustments	Satisfied rate (%)	Explant rate (%)	Complication rate (%)	Major complication rate (%)	Baseline pad count (pads/day)	After adjustment pad count (pads/day)	Baseline pad test (mL/ day)	After adjustment pad test (mL/day)
Bauer and Brössner [16]	120	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Seweryn et al. [17]	38	0–1 PPD <15 mL	60.5	84.2	3.97 (0–9)	NA	10.5	NA	15.8	6.78 (2–10)	1.36 (0–10)	747 (230–1600)	115 (0–1500)
Hoda et al. [18]	124	0–1 PPD	61.6	93.8	4.3 ± 1.8	NA	4	8.9	NA	8.8 ± 3.8	1.8 ± 1.2	725 ± 372	NA
Hoda et al. [19]	99	0–1 PPD <10 mL	63	92	3.8 ± 1.3	NA	4	NA	NA	7.1 ± 2.3	1.3 ± 1.1	681 ± 466	79.7 ± 210
Krause et al. [20]	36	0–1 PPD	39	50	NA	61.8	30.5	44.4	NA	8.33	4.4	NA	NA
González et al. [21]	13	0 PPD	92.3	87.1	NA	100	0	NA	NA	NA	NA	NA	NA
Friedl et al. [22]	34	0–1 PPD	56	88	NA	NA	11.8	17.6	NA	3.5 ± 0.2	1.5 ± 0.3	NA	NA
Muhlstadt et al. 2016 [23]	54	0 PPD	48.1	77.7	4.5 ± –2.3	NA	7.4	25.9	NA	7.7 ± 4.8	1.6 ± 1.7	NA	NA
Friedl et al. [24]	62	0–1 PPD	61.3	90	1.5 ± 1.2	NA	14.5	6.45	NA	4 (3–5)	1 (0–2)	350 (300–542)	5 (0–135)
El Badry et al. [25]	9	0 PPD	77.8	89.9	1	NA	0	22.2	NA	4.6 (3–6)	0 (0–2)	747 (230–1600)	NA
Hüsch et al. [26]	49	NA	NA	NA	NA	NA	2.0	14.2	2.0	NA	NA	NA	NA
Buresova et al. [27]	35	0–1 PPD	62.9	100	4.3 (1–15)	NA	2.9	20	NA	5	1	NA	NA
Friedl et al. [28]	287	0–1 PPD <10 mL	64	NA	3 (2–4)	NA	19.5	7	2	4 (3–5)	1 (0–2)	400 (300–700)	18 (0–105)
Friedl et al. [29]	49	0–1 PPD <10 mL	57.1	89.7	2 ± 1	NA	19.5	34.7	16.3	4 (3–6)	1 (0–2)	458 (310–630)	10 (0–90)
Angulo et al. [30]	34	0–1 PPD	85.3	95	1 ± 3	97	0	14.7	NA	5 ± 3	0 ± 0	510 ± 500	0 ± 15

Manso et al. [31]	25	0-1 PPD	64	100	1.54 ± 1.3	84	0	NA	4	4.84 ± 2.95	1.6 ± 2.02	NA	NA
Angulo et al. [32]	215	0-1 PPD <10 mL	80.5	85.1	1.4 ± 1.9	85.1	3.25	15.3	3.7	3.9 ± 2	0.9 ± 1.5	484 ± 372	63.5 ± 201
Esquinas et al. [33]	60	0-1 PPD	81.7	93.3	1 ± 2	93.2	1.7	18.6	NA	5 ± 3	0 ± 1	465 ± 450	0 ± 20
Angulo et al. [34]	20	0-1 PPD	75	91.5	1 ± 3	80	0	15	NA	4 ± 3	0 ± 1.5	375 ± -855	10 ± 32.25
Angulo et al. [35]	30	0-1 PPD	76.7	100	1 ± 1	83.3	3.3	13.3	NA	4 ± 3	0 ± 1	435 ± 393	10 ± 30

patients with mild to moderate incontinence implanted with ATOMS also revealed improved sexuality and erectile function [22]. Another series with predominance (68.5%) of severe incontinence confirmed high-grade incontinent patients profit significantly from ATOMS therapy, both in pad-count and QOL assessment. The mean pad-count decreased from 7.7 to 1.6 and the success rate was 77.7% (48.1% dry and 19.6% improved) at mean 27.5 months follow-up [23]. Other small series of patients treated with ATOMS showed excellent results [25, 27] and the security profile of ATOMS was indirectly compared to that of AUS and resulted beneficial [26].

In 2016 another multicenter cohort investigated risk factors for ATOMS treatment failure and removal at 17.7 months median follow-up and identified positive urine culture, SUI severity and secondary surgery as independent factors in multivariate analysis [29]. Later long-term outcomes with ATOMS were reported in the largest multicenter study performed to date, showing superiority of SPP device over its predecessors, and also better results in primary implantation and in patients without radiotherapy. After a median follow-up of 31 months, with a median 3 adjustments, the overall success rate was 90% and dryness rate 64%. Daily pad-test and pad-count decreased from a median 400 mL and 4 pads to a median 18 mL and 1 daily pad [28]. In 2018 a multicenter retrospective study performed in 9 Iberian institutions [32] and several single center experiences with predominant SSP device [30, 31, 33] described excellent short-term results for continence recovery and satisfaction in patients with bothersome and very bothersome SUI with the SSP ATOMS. These series also have in common very high patient satisfaction perceived with different tools to assess patient reported outcomes. The results derived from the multicenter Iberian study showed a daily pad-count decrease from 3.9 to 0.9 and a daily pad-test change from 484 to 63.5 mL. Dry rate after adjustment was 80.5% (56.3% used no pads and 24.2% used a security pad/day with urine loss <10 mL. Dry rate according to SIU severity was 96.2% for mild incontinence and 75.3% for

moderate-severe incontinence. Satisfaction rate with the procedure was 85.1% SUI) [32].

Treatment of male SUI after TURp, either primary or after radiotherapy, with ATOMS reports resulted similarly to when treating SUI after radical prostatectomy [29, 34]. It is also a matter of debate whether radiated patients have worse results with ATOMS. Some authors have recognized similar outcomes in this population when compared to non-irradiated patients [17, 19]. Conversely, we found worse objective results after irradiation but not worse patient satisfaction [31–33]. ICIQ-SF and PGI-I, are considered useful tools to evaluate patient reported outcomes with ATOMS [28, 30, 32, 33].

A systematic review and meta-analysis with data from 1393 patients of the existing non-randomized clinical trials showed high heterogeneity but revealed very interesting information on standardized pooled data regarding the acquisition of dryness (67%) and improvement of continence (90%), together with objective measurements of ATOMS efficacy such as -4.14 daily pad-count change and -443 mL daily pad-test change, both between baseline and after adjustment. Heterogeneity was dependent on the proportion of radiated patients included, baseline severity of incontinence treated and different generations of the device used. Better dry rate was evidenced for patients with less than 6 pads per day before implant, patients without irradiation and with use of SSP device [36].

Long-term durability for the device is one of the main questions that remains unanswered. However, many patients have been taking their device for 5 years now and studies dealing this issue reveal that, at least in the short-term durability of the device is reassuring [32]. Figure 64.4 shows an ATOMS system in place with 21 mL filling of the system after 3 postoperative adjustments. This patient had baseline 870 mL daily pad-test urine loss and is totally dry 5 years later. Magnetic resonance imaging (MRI) gives a good understanding of the position of the cushion and how the ventral compression on the bulbar urethra is exerted.

Another key point is that self-assessed satisfaction with ATOMS is very high. According to

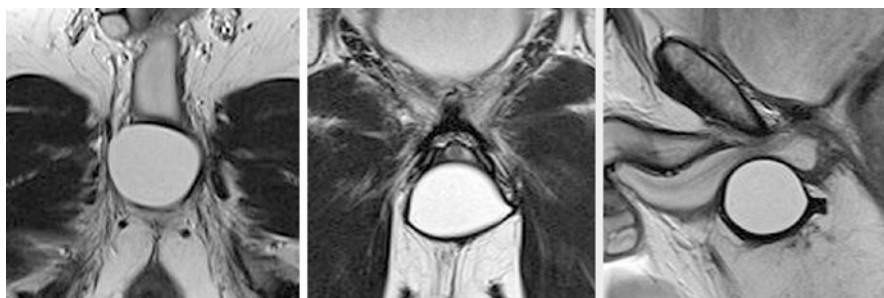


Fig. 64.4 Magnetic resonance imaging (MRI) shows postoperative location of the ATOMS cushion and ventral compression on the bulbar urethra. From left to right image reveals axial, coronal and sagittal views

a recent report factors that predict best perception of improvement include dryness, baseline SUI severity, presence of complications and pain level during admission. Radiotherapy and device generation were not independent predictors. Taking these factors into account a nomogram to predict patients that are completely satisfied with ATOMS after adjustment has been proposed [38].

In summary, accumulated including a fair amount of severely incontinent patients [17, 19, 23, 32, 33] indicate that AUS should no longer be considered the single choice for severe male SUI. Also, the good results with ATOMS in selected patients with previously failed AUS [19, 24, 35] confirm ATOMS is also an alternative for severe male incontinence, and it should be first choice in patients with diminished hand dexterity or cognitive deterioration. Optimizing health resources implies the need to identify the most appropriate treatment for a particular patient profile.

64.7 Complications

Intraoperative complications with ATOMS are very rare and most series have none. Major visceral lesions at the exit of the tunneler outside the ischiorectalis fossa have not been reported in the literature. Small intraoperative bleeding outside the ischiorectalis fossa is sometimes present and usually needs no specific care, once lesion of bulbar artery or vein have been discarded, as tightening of the cushion to the mesh with the attachment

sutures ends the bleeding. Hemostatic agents, such as Floseal®, could be placed inside the plastic cover of the mesh before extraction, but this maneuver is more theoretical than a real need. We have never had a real bleeding problem with the insertion of the device. Perineal compression is advisable as no postoperative drainage system is left. Care should be taken to re-start oral anticoagulation therapy to avoid severe hematoma (Fig. 64.5).

Postoperative complications are variable in the different series reported with a pooled mean 16% according to Clavien-Dindo classification system [36]. They include perineal hematoma, pain, transient dysesthesia, epididymitis, device infection, skin erosion and explantation [32]. The proportion of patients with device explanted as reported in the literature was 5.75% [36]. There is a discussion whether SSP system is less prone to complications as it is inserted through a single incision, and also if silicone covering of the port avoids problems derived from titanium contact; however, it is difficult to know whether the reduced rate of complications is due to the system itself or to a learning curve effect with the use of the device. ATOMS placement is a very simple surgery but great care to avoid infection must be always kept regardless the experience with the system (Fig. 64.5).

Device explant is mainly due to device infection or port erosion and more rarely to malfunction or pain [24]. Easiness of postoperative adjustment is one of the main strengths of ATOMS device. However, filling of the system must be kept to a reasonable limit as device dislocation

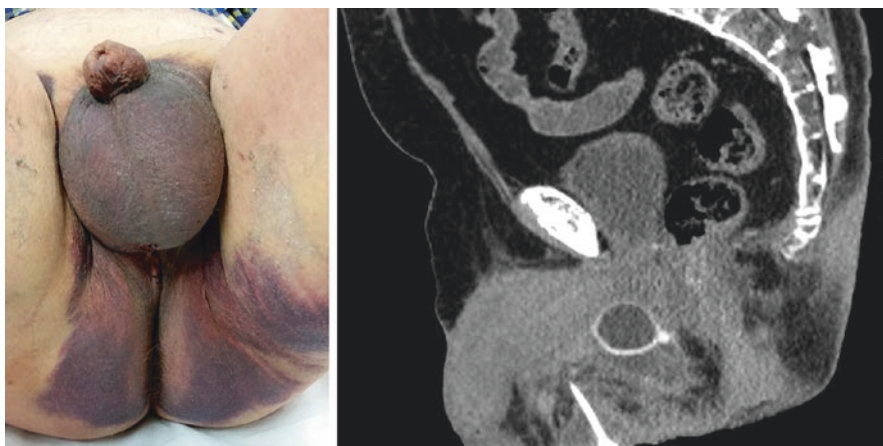


Fig. 64.5 Scrotal hematoma 3 days postoperatively in a patient on dicumarin anticoagulant therapy (left). Device infection evidenced in another patient as perineal collection on CT-scan 5 weeks postoperatively (right)

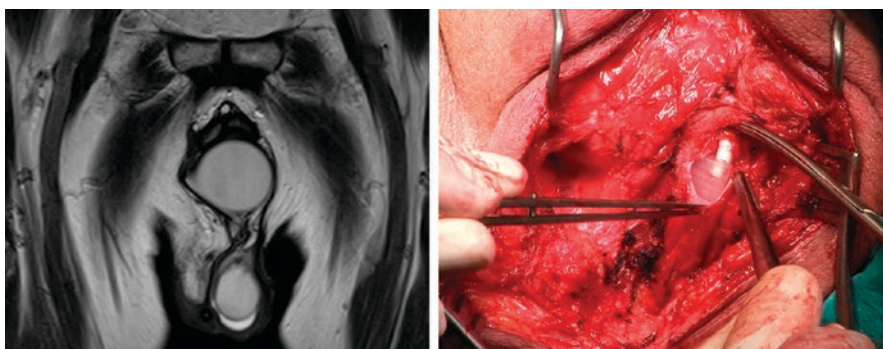


Fig. 64.6 Device dislocation of the cushion with 38 mL, leading to late failure of the device. Daily pad-count initially changed from 4 diapers to 2 pads, but willing total

dryness the cushion was overfilled and incontinence worsened. Loss of fixation was confirmed and a new ATOMS device was placed

due to overfilling of the cushion with lateralization of the device and ineffective compression on the urethra can be a reason for late failure (Fig. 64.6). Scrotal skin erosion can be due to inadequate dissection of the dartos fascia when placing the port and this is one of the sources of device infection. Early diagnosis of this complication can lead to surgical exploration before erosion with washing and salvage of the device as port can be knot-tied and excised if the patient is already continent at the time of surgical exploration (Fig. 64.7). If not, once infection is controlled a new port can be inserted to allow late postoperative adjustment of the device. Also, some patients with old generation device (non-silicone covered SP) may suffer long-term leak-

age of the saline solution thus losing urethral compression and leading to ineffectiveness. This anecdotal situation does not happen in late generation devices. It may be caused by altered material porosity and can be palliated by mixing saline infusion with iodine contrast agents that collaborate in sealing the membrane. Due to its simplicity mechanical failure of the device is very rare; however, cushion can break, at least hypothetically, after perineal trauma or intraoperative unnoticed puncture.

Preoperative selection of patients with negative urine culture, careful technique avoiding rotation of different surgeons, intraoperative gentamicin irrigation and antibiotics maintained in the early postoperative period surely contributed

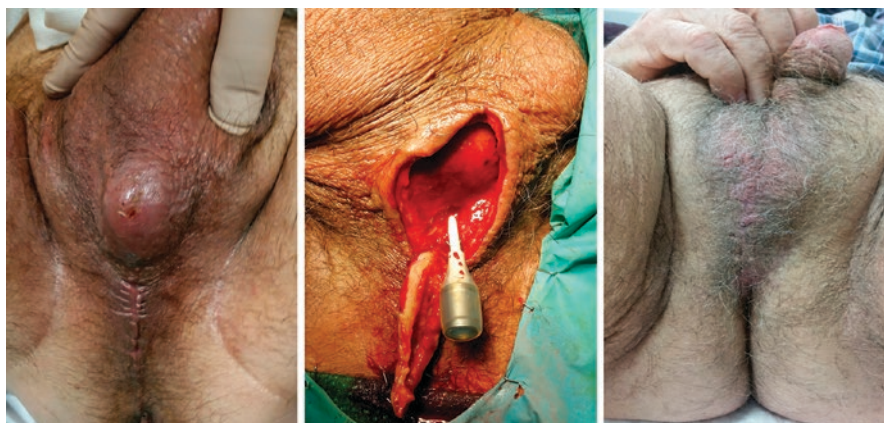


Fig. 64.7 Scrotal port erosion treated by port tube ligation and scrotal skin reconstruction. The patient was continent and device was rescued with this maneuver

to the absence of infective or rejection-related complications. Most series lack urethral erosion because bulbospongiosus muscle is not dissected and compression is not applied circumferentially as in AUS. Possibly higher intraoperative filling of the cushion diminishes the need and numbers of postoperative adjustments, and that might also contribute to lower risk of infection.

64.8 Atoms after Failed Devices

The ATOMS system works on a similar compressive principle as AUS but urethral closure is only ventral and not circular, thus leaving the dorsal and lateral blood flow intact. This difference implies that the risk of urethral erosion is almost absent with ATOMS, and that makes this device very attractive for patients with fragile urethra (pelvic radiation, previous urethroplasty, urethral atrophy). Besides, the opportunity of postoperative adjustment and the fact that the patient does not manipulate the device are also advantageous. Within ATOMS literature urethral erosion has been reported only twice, in a case associated to perineal infection and in another patient who had undergone surgery for incontinence on 4 separate occasions and had experienced erosion of an AUS 6-months before receiving the ATOMS implant [17, 20]. No more cases were reported in any other series so far.

A small cohort of patients exclusively reported on the use of ATOMS as secondary implantation

revealed similar results to primary implant with few complications and good patient reported outcomes [35]. The very interesting scenario of ATOMS after urethral erosion is possibly the most interesting aspect of this cohort. Hoda et al. were first to consider secondary use of ATOMS as one third of their patients had failed previous surgeries including AUS, ProAct, several slings and bulking agents. More specifically 49% with failed AUS were dry and 28% improved, and 59% with failed sling were dry and 27% improved [19]. secondary and tertiary implantation of ATOMS is feasible, especially after device removed because of infection or device dislocation (Fig. 64.8). Friedl et al. found that secondary use of ATOMS appeared at higher risk of failure than primary use. However, former urethral surgeries and strictures did not influence device durability [24].

Taking the consolidated results of ATOMS and the scarcity of local complications into account, ATOMS merits specific evaluation as an alternative to failed AUS and failed male slings in large scale studies. The low risk of urethral erosion and other post-operative complications in this scenario with ATOMS favors its choice in patients with fragile urethra, as it does not cause urethral atrophy and is subject to less mechanical failures and need of revision surgery than AUS. Ultimately the decision must be individualized and consider patient's expectations and the risks of further complications.

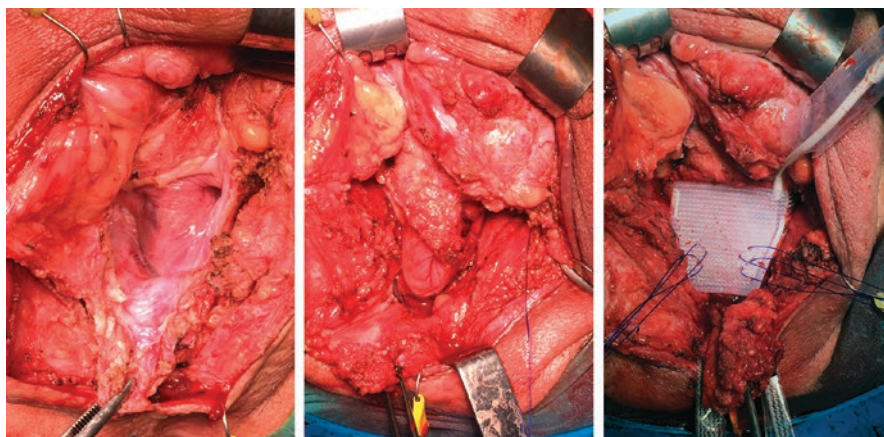


Fig. 64.8 ATOMS replacement surgery. A pseudo-capsule surrounds the extracted device. Tunneler passage and cushion position are very alike a primary implant. Once tied the pseudo-capsule is used to cover the device

64.9 Conclusions

Adjustable Transobturator Male System (ATOMS) is a useful and secure prosthetic device to treat stress urinary incontinence (SUI) after prostatectomy, used for more than a decade. A transobturator polypropylene mesh tied to a central silicone inflatable cushion exerts ventral urethral compression and is connected to a filling port subcutaneously placed. Progressively post-operative adjustment is performed if needed by the simple injection of sterile saline solution into the port, without need for anesthesia or radiation. It opens a new perspective of treatment for patients with male SUI of any degree, and it may be the best option in patients with mild-moderate SUI severity and also for patients with limited dexterity or cognitive impairment, as no manipulation is required.

A systematic review and meta-analysis with data from 1393 patients revealed very interesting information on standardized pooled data regarding the acquisition of dryness (67%) and improvement of continence (90%), together with objective measurements of ATOMS efficacy such as -4.14 daily pad-count change and -443 mL daily pad-test change. Better dry rate was evidenced for patients with less than 6 pads per day before implant, patients without irradiation and last generation device with silicone covered scrotal port. Patient reported outcomes show very high level of satisfaction with

the device. ATOMS is of paramount indication in the fragile urethra, as bulbo-spongiosus muscle is not dissected and urethral compression is not circumferential. ATOMS is also an attractive option after failed male sling or artificial urinary sphincter.

Key Summary Points

- Adjustable Transobturator Male System (ATOMS) is a self-anchoring transobturator device composed of a polypropylene mesh for outside-in transobturator passage and a central silicone inflatable cushion connected to the port that is subcutaneously placed in the scrotum.
- ATOMS can be progressively adjusted postoperatively by the simple injection of sterile saline solution into the port, without need for anesthesia or radiation during adjustment.
- ATOMS is an ideal treatment for patients with mild-to-moderate male stress urinary incontinence, but also for severe SUI in selected patients.
- ATOMS is the best option in patients with limited dexterity or cognitive impairment as no manipulation is required. It can be used also after irradiation and in patients with former urethroplasty, previous

healed urethral erosion and failed sling or artificial urinary sphincter.

- Simplicity of the surgery is associated with a very short learning curve.
- Clinical outcomes published on ATOMS reveal very interesting information on standardized pooled data: dryness is acquired in 67% of the patients, continence improves in 90%, daily pad-count is reduced in 4.14 pads/day and daily pad-test in 443 mL comparing baseline and after adjustment.
- Major complications with ATOMS are rare. Urethral erosion and atrophy do not take place because bulbo-spongiosus muscle is not dissected, and device does not apply a circumferential compression on the urethra.
- ATOMS explant has been reported in 5.75% of the cases published and durability is reassuring in the short term. Infections can be reduced with meticulous perioperative care and pre-operative negative urine culture.
- Patient reported satisfaction with the procedure is very high.

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Treatment of Male Stress Urinary Incontinence: Artificial Urinary Sphincter

65

Roy Lipworth, Brian J. Linder, and Daniel S. Elliott

65.1 Introduction

Stress urinary incontinence (SUI) is defined by the International Continence Society as the complaint of involuntary leakage on effort or exertion, or on sneezing or coughing [1]. Any surgical or radiotherapeutic manipulation of the external urinary sphincter may result in SUI, with radical prostatectomy (RP), transurethral resection of the prostate (TURP), and radiation therapy accounting for the majority of iatrogenic etiologies [2].

Primary surgical management of men with persistent, bothersome stress urinary incontinence (SUI) either with urethral sling placement or artificial urinary sphincter (AUS) placement, is typically highly successful [3, 4]. However, as with most surgical procedures, appropriate patient selection and counseling are a crucial component to obtaining excellent outcomes. Here, we review the preoperative considerations, operative technique, postoperative outcomes, and complications for artificial urinary sphincter placement.

65.1.1 Background and Design

Originally introduced in 1974, the AUS is the most efficacious option in the surgical management of severe male stress urinary incontinence [5]. In the United States, AUS implantations represent approximately 12% of anti-incontinence procedures performed for men with urinary incontinence [6]. This may be secondary to risks of the procedure and/or patient preferences regarding implanting a mechanical device [7].

The most commonly implanted AUS model is the AMS 800 (Boston Scientific, Marlborough, MA), which consists of three components: an inflatable urethral cuff, a scrotal pump, and an abdominal reservoir/ pressure-regulating balloon. (Fig. 65.1) When cycled, the scrotal pump shunts fluid from the urethral cuff to the abdominal reservoir, thus decreasing the pressure in the urethral cuff and allowing the urethra to be patent for voiding. A refill-delay resistor maintains the urethral cuff in this open state to permit voiding for 60–90 seconds and then allows the fluid to be transferred back to the cuff to maintain continence. (Fig. 65.2) The scrotal pump also contains a deactivation button at its superior aspect which allows the cuff to be placed into a locked “deactivated” position. Such a feature is needed in the event a patient is to undergo catheter placement or cystoscopy. It can also be potentially used for nighttime deactivation in an effort to reduce urethral atrophy [8]. Device activation from the

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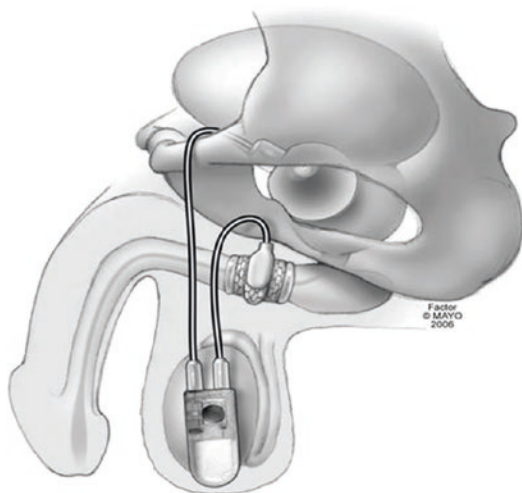


Fig. 65.1 Representative illustration of an artificial urinary sphincter including: urethral cuff, abdominal reservoir, and scrotal pump

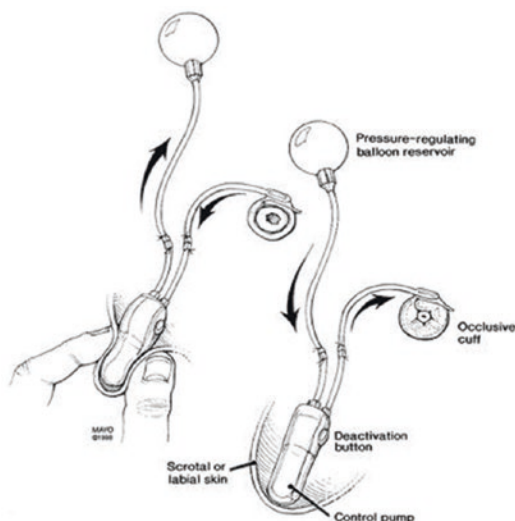


Fig. 65.2 Representative demonstration of artificial urinary sphincter pump cycling

locked state is achieved by squeezing the scrotal pump (as with normal cycling), which forces the deactivation button out of the locked position and restores the typical AUS functions. It is worth noting that a deactivated device can easily be identified on physical exam due a dimpling in the pump since it is not completely full (as it would be in the activated state).

65.2 Clinical Evaluation

Males presenting with bothersome stress urinary incontinence should undergo a history and physical examination with attention paid to the duration of time from any surgical or radiotherapeutic manipulation of the external urinary sphincter, noting any change or improvement in continence over time. Also worth noting are stress versus urge incontinence symptoms, a history of underlying urologic pathology (e.g. urethral stricture, urothelial malignancies, prior urolithiasis, etc.), a history of hematuria or urinary tract infections, and any prior genitourinary treatments (including pelvic radiation). Notably, a consensus panel on AUS implantation advocated for a waiting time of 6 months following surgery in cases of severe (i.e. gravitational) incontinence that are not improving with conservative management [9]. They noted that if the patient's incontinence is progressively improving, even at 12 months, surgical therapy can be delayed at the surgeon's discretion [9]. Additional further evaluations of the patient's degree of incontinence (e.g. pad weight, validated questionnaires, etc.) may be employed per the discretion of the treating physician.

With regard to potential artificial urinary sphincter placement, specific attention during the physical exam should be focused on the patient's capacity to potentially manipulate the device. In elderly patients, acceptable AUS success rates have been reported provided that they have the mental and physical capacity to justify device placement [10, 11].

65.2.1 Additional Testing

The extent of additional testing may depend on which treatment for incontinence the patient wishes to pursue. In all patients, we perform a urinalysis and noninvasive uroflow test with post void residual to assess for active urinary tract infection and incomplete bladder emptying. Likewise, we typically perform cystoscopy to evaluate for urethral stricture,

vesico-urethral anastomotic stenosis, or other urothelial pathology. Further testing including imaging (e.g., history of nephrolithiasis, urothelial carcinoma, hematuria), urine cytology (e.g., irritative lower urinary tract symptoms, history of urothelial carcinoma), and PSA may be obtained as clinically indicated. While we do not routinely perform complete multichannel urodynamic studies in those interested in AUS placement, these are used in cases with suspicion of altered bladder compliance (e.g. prior radiation, neurologic disease, etc.) or urge-predominate mixed urinary incontinence. By comparison, urodynamic evaluation, including an evaluation of detrusor contractility, may be more useful in those interested in compressive urethral sling placement.

Patients with prior histories of urothelial carcinoma, urethral stricture disease, and anastomotic stenosis among others, should demonstrate a sufficient period of disease stability prior to consideration of AUS placement to reduce the risk of erosions resulting from subsequent repeated cystoscopic interventions.

65.2.2 Urethral Sling Versus AUS

Depending on the results of the preoperative evaluation, patients can consider treatment with a urethral sling or AUS. The decision regarding which procedure to perform in males presenting with stress urinary incontinence is based on several factors, including patient preferences [7]. Notably, for optimal outcomes with male urethral sling placement, patient selection is crucial. In that regard, several factors have been associated with increased rates of persistent stress urinary incontinence following sling placement including pad weight greater than 450 grams per day, previous pelvic radiation therapy, and a low detrusor leak point pressure [12]. For these patients, or those who have failed a prior urethral sling, AUS placement may achieve greater continence when patient capability and preferences permit.

65.3 Operative Technique

65.3.1 Approach and Preparation

In terms of the surgical technique for AUS placement in males, we prefer to use a perineal approach, with patients in the dorsolithotomy position and placement of the urethral cuff around the proximal bulbar urethra. Penoscrotal techniques for AUS implantation have been described, but in our experience these tend to lead to more distal cuff placement and subsequent revisions. In fact, a multicenter study found that there is a higher completely dry rate, with fewer subsequent revision surgeries, with a perineal approach than with a penoscrotal approach [13].

For the surgery, the skin is prepped with Chlorhexidine, as this has been associated with lower device infection rates than a povidone-iodine preparation [14]. Intravenous antibiotics are administered within 60 minutes prior to incision; we prefer the use of vancomycin and an aminoglycoside. Draping is performed based on a “no-touch” technique using Ioban, as described in the penile prosthesis literature [15]. We then place a 12 Fr urethral Foley catheter to drain the bladder and proceed with the perineal dissection.

65.3.2 Cuff Placement

We perform circumferential dissection of the proximal bulbar urethra between the corpora cavernosum and corpora spongiosum and leave the bulbocavernosus muscle intact. (Fig. 65.3) The urethra is then assessed to ensure that no urethrotomy has occurred during the dissection. We perform this via pericatheter injection of saline, with the Foley on slight tension to occlude the bladder neck, and evaluation for extravasation. The urethra is then measured and the appropriate sized urethral cuff is selected. In cases of severely atrophic urethral tissues (3.5 cm or less) or difficult dissection planes (e.g. in some cases with prior pelvic radiation therapy or urethral sling

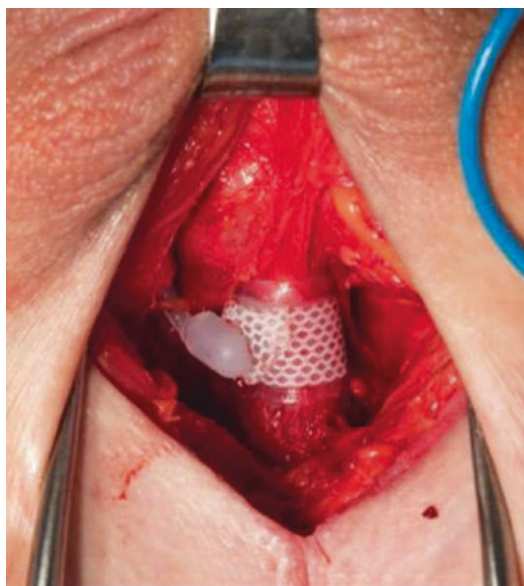


Fig. 65.3 Intraoperative photo demonstrating the perineal dissection and placement of the urethral cuff at the proximal bulbar urethra

placement), we utilize a transcorporal approach [16, 17]. Notably, we do not place tandem urethral cuffs as primary implantations. This practice is supported by evidence that tandem cuff placement may lead to a higher rate of subsequent revisions than single cuff placement [13, 18, 19]. In addition, this approach allows us to reserve tandem cuff placement for future revisions secondary to urethral atrophy, if needed.

65.3.3 Reservoir and Pump Placement

Following completion of the urethral dissection, attention is turned to placing the abdominal reservoir and scrotal pump. We use a separate abdominal incision for ectopic submuscular/preperitoneal placement of a 61–70 cm abdominal reservoir. The reservoir can be filled with either normal saline or iso-osmotic contrast. In our practice, 22 cc of iso-osmotic contrast, a water/contrast mix of 48 ml iohexol (Omnipaque 350) and 60 ml sterile water, is instilled in the reservoir at the time of placement to assist with identification of mechanical failure during future evaluations if

they are needed for recurrent stress incontinence [20]. The scrotal pump is placed in the anterior scrotum on the side of the patient's dominant hand (and the same side as the tubing of the other components), in an effort to avoid difficulty with pump manipulation. A clamp is passed from the abdominal wound to the perineal wound to retrieve the urethral cuff tubing. Excess tubing is trimmed and the Quick Connector System is used to complete the connections between the tubing from the three components [9].

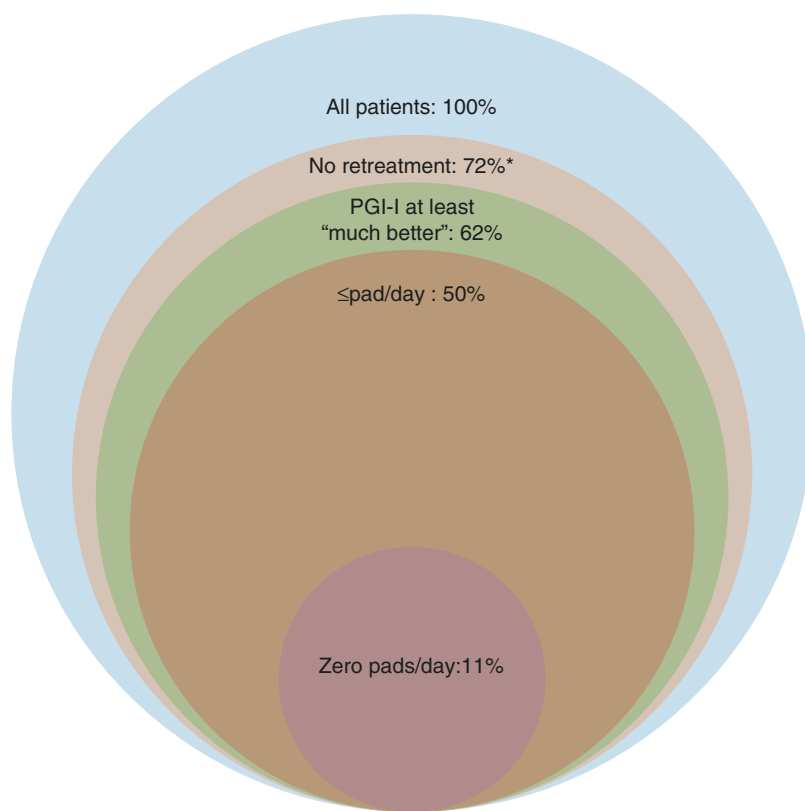
65.3.4 Post-op

At the end of the procedure, the device is left in the deactivated position and the 12 Fr Foley catheter is left indwelling. In our practice, patients stay overnight in the hospital for observation and their catheter is removed the morning following surgery. After a voiding trial, the patient is instructed on pulling the scrotal pump to a dependent position twice daily until their 6-week follow-up visit. At the 6-week visit the device is activated and patients are instructed on routine use.

65.4 Outcomes

While there are numerous surgical series of patients treated with urethral sling placement or artificial urinary sphincter implantation, it is admittedly difficult to compare outcomes between reports. This is secondary to a lack of standard methods for reporting the degree of incontinence or criteria to define “success” in the available studies. Various objective, subjective, or retreatment definitions have been utilized with varying association to surgical success [21]. These include the Patient Global Impression of Improvement (PGI-I), the Michigan Incontinence Symptom Index (M-ISI) score, and pad counts. The Venn diagram in Fig. 65.4 illustrates the large variability between success rates depending on the definition of success in 309 males who underwent primary AUS placement at our institution from 2010 to 2016 [21].

Fig. 65.4 Venn diagram illustrating success rates of AUS placement using four definitions of success. Percentages are calculated from total population $n = 309$



*Patients with retreatment were also considered to have failed by all other definitions

In addition, the majority of studies have poorly-defined or undefined inclusion/exclusion criteria, with significant heterogeneity of the patient populations, including inconsistent inclusion of patients with varied etiologies for stress incontinence and variable lengths of follow-up. These factors, among others, limit the ability to draw comparisons between studies and surgical techniques.

Notably, despite variation between studies, the current literature consistently demonstrates high long-term success rates for primary AUS implantation [3, 19, 22–26]. That is, a recent pooled-analysis showed an overall re-intervention rate of 26% (range 14.8–44.8%) [3] and a 5 year AUS device survival ranging from 59% to 79% [3, 19, 22–26]. Furthermore, in the few available studies, the reported 10-year device survival rates range from 28% to 64% [4, 22, 25, 27]. For instance, in a review of 124 patients, with a median follow-up of 6.8 years, Kim et al. found

an overall revision rate of 37% [27]. Additionally, with regard to functional outcomes, a recent systematic review evaluating patients with non-neurogenic etiologies for incontinence leading to AUS placement in studies with a minimum of 2 years of follow-up noted a “dry or improved” rate of 79% (range 61–100%) [3]. Likewise, high levels of patient satisfaction (over 90%) following AUS placement are commonly reported, though the rate of continence decreases over time [3, 4, 28].

Data regarding outcomes beyond 10 years in the literature is sparse [4, 22]. In the two available series, the 15-year device survival rate was 15% and 41% [4, 22]. In the series by Leon et al., which included 57 men that underwent AUS placement over an 8 year period and had a median follow-up of 15 years, the AUS survival rates without revision were 59%, 28%, 15% and 5% at 5, 10, 15 and 20 years, respectively [22]. This study was unique in that the authors noted that no

patients were lost to follow-up. In our own retrospective series of 1082 primary AUS implantations performed at our institution, we found 5, 10 and 15 years device survival rates of 74%, 57% and 41%, respectively [4]. As mentioned above, differences in device survival between series may be due to disparate patient populations, length of follow-up available, patient loss to follow-up, and surgical technique.

65.4.1 Pelvic Radiation and AUS Outcomes

With regard to device outcomes, numerous studies have attempted to identify potential risk factors for adverse AUS device survival [26, 29–38]. A comorbidity that is frequently discussed is receipt of pelvic radiation prior to AUS implantation [29–33]. This is a common clinical scenario as we have found that 37% of patients that underwent AUS in our practice had received prior pelvic radiotherapy [30]. The studies available in the current literature evaluating the association of radiotherapy and device survival have met with conflicting results [29–33]. However, in a recent meta-analysis of 15 series, including 1886 patients, men with a history of radiation therapy in addition to prostatectomy had a higher rate of AUS revision than those treated with prostatectomy alone [33]. The majority of the surgical revision risk was secondary to device infection and urethral erosion events. Likewise, patients with prior radiation therapy were more likely to have persistent urinary incontinence after AUS placement [33]. Given the available AUS literature, many of these studies were small retrospective series, and the authors noted a high level of heterogeneity. Notably, when subanalyzing without the four largest studies, in an effort to decrease heterogeneity, the relative risk of surgical revision was no longer significantly different between those with or without prior radiation therapy [33]. A recent analysis of 925 patients in our practice who underwent primary AUS placement from 1983 to 2011 found no association between pelvic radiation therapy with prostatectomy and increased risk of device infection or erosion when

compared to prostatectomy alone. The size of this study is significantly larger than the four studies that were excluded in the subanalysis of the study discussed above [39].

Further studies, including those focused on functional outcomes and quality of life are needed to better define the impact of prior radiotherapy on AUS outcomes and to provide useful information for better patient counseling. It should be noted that patients treated with pelvic radiation therapy should not be excluded from receiving an AUS solely based on this comorbidity.

65.4.2 AUS Following Failed Urethral Sling

Many men prefer urethral sling placement even if they are not ideal candidates. This preference may stem from a desire to avoid a mechanical device, the risks of device malfunction or erosion, and the need for AUS manipulation and replacement over time [7]. For patients with persistent or recurrent stress urinary incontinence after male urethral sling placement, revision surgery either via repeat urethral sling or, more commonly, AUS placement have been reported [40–44]. In this setting, placement of an AUS is typically utilized as the presence of fibrosis hinders urethral compression and/or mobility which are important for sling efficacy [12, 45, 46].

Several reports have demonstrated, albeit in small series, excellent outcomes for AUS placement after a previous urethral sling [41–44]. For instance, similar high success rates with limited complications were seen in a series of 28 patients undergoing AUS after a failed urethral sling when compared to a control group without prior urethral sling surgery [42]. Likewise, in a comparative analysis of patients with stress urinary incontinence after a failed urethral sling, patients undergoing repeat urethral sling placement (transobturator) were six times more likely to have persistent incontinence than those who had an AUS [41].

In cases of failed urethral sling placement, our preference is to place an AUS. Notably, in our

experience, in the majority of these cases, the sling can be left in situ without need for excision. If the sling is encountered, we prefer to incise the sling rather than perform urethrolysis as this risks urethral injury and may potentially compromise urethral blood supply.

65.5 Complications Following AUS Placement

65.5.1 Urinary Retention and Hematomas

Perioperative or early postoperative complications following AUS placement most commonly consist of urinary retention, scrotal hematoma and device infection/urethral erosion. In our prospective series of postoperative AUS complications, urinary retention was most common [47]. Postoperative urinary retention following AUS placement is thought to be secondary to urethral edema from the periurethral dissection, error in cuff sizing, or unrecognized surgical injury. Interestingly, in our series, transient postoperative urinary retention was associated with adverse overall device survival and a significantly increased rate of AUS infection/urethral erosion [47]. In cases of post-operative retention following catheter removal the morning after surgery, we teach patients to perform intermit-

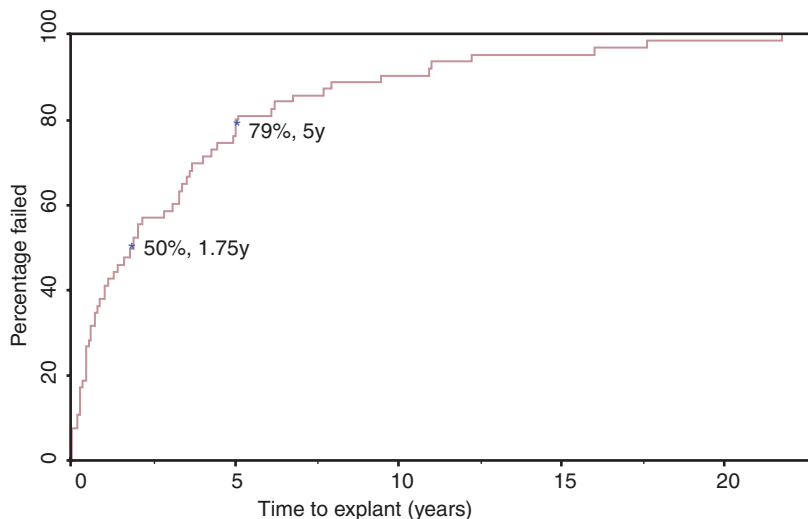
tent self-catheterization with a 12 Fr catheter. Other options include leaving an indwelling catheter for a short period of time (24–48 hours) or suprapubic tube placement if retention is longer lasting [9]. Notably, while prolonged catheterization (greater than 48 hours) is reported to increase the risk of erosion, data regarding the potential impact of self-catheterization on AUS outcomes in a non-neurogenic adult population is sparse [48, 49].

Scrotal hematomas may range in size and severity, though most can be managed conservatively. In patients having difficulty with pain control, large/expanding hematoma size, concern for infection, or issues with pump position, hematoma evacuation may be warranted.

65.5.2 Infection and Erosion

In a recent pooled analysis, device infection or urethral erosion was reported to occur in 8.5% of cases (3.3–27.8%) [3]. Notably, not all series included distinguished between device infection and urethral erosions. A recent study of 1082 patients who received primary AUS placement from 1983 to 2011 at our institution showed a 5.8% urethral erosion rate with a median time to explantation of 21 months. As evident in Fig. 65.5, the temporal trend of AUS erosions demonstrated a peak within 1–2 years and gradual

Fig. 65.5 Time to artificial urinary sphincter explantation secondary to urethral cuff erosions



tapering thereafter [50]. Still, continued monitoring is needed to decrease late erosions.

AUS device infection may be secondary to intraoperative contamination or unrecognized urethral erosion. The most commonly isolated organisms during device explantation for infection include *Staphylococcus aureus* (including MRSA), *Staphylococcus epidermidis*, *Enterococcus*, and gram-negative bacilli such as *Pseudomonas aeruginosa* and *Escherichia coli* [51]. When infection is encountered, the entire device should be explanted [9].

Urethral erosions occurring early in the postoperative period are likely secondary to unrecognized urethral injury or shallow dissection occurring at the time of surgical implantation. Later erosions may occur secondary to progressive urethral atrophy or traumatic catheterization. Device erosions require explantation of all three components due to potential colonization from the exposed component. Pending adequate recovery and cystoscopic verification of the absence of urethral stricture development, salvage re-implantation several months later is feasible. Re-implantation in this setting, however, is associated with an increased risk of repeat infection/erosion [26, 35].

65.5.3 Recurrent Incontinence

In addition to early complications, patients may present with recurrent incontinence following AUS implantation. Persistent/recurrent stress incontinence can be broadly categorized into: improper device utilization, mechanical and non-mechanical failures, or non-device related causes. Device malfunction has been reported in 6.2% of cases (2–13.8%) [3]. Malfunction can be identified on physical exam with improper device cycling and lack of coaptation of the urethral mucosa during cystoscopy. In addition, imaging with either an abdominal x-ray (if contrast was used to fill the system) or ultrasound (if normal saline was used) will confirm the diagnosis [52, 53]. It should be noted that without a baseline film for comparison, roughly 50% of the contrast would need to extravasate from the

abdominal reservoir before changes in the reservoir contour may be detected on plain x-ray [52]. One benefit to filling the system with contrast is that an immediate postoperative x-ray allows for prompt recognition of inadequate device filling or issues with connectors.

Given the limited data available on the surgical treatment of AUS mechanical failures, significant heterogeneity exists regarding management recommendations in the current literature [20, 23, 24, 53–56]. For instance, some authors have suggested that the entire device be removed if it malfunctions after the device has been in place for 2–5 years (with single component revision prior to the time cutoff). These guidelines are largely based on the median time to device malfunction [23, 24, 54, 56]. Conversely, others argue in favor of replacing the entire device in all cases due to limited added surgical risk compared to single component revision. The possibility of debris entering the tubing and concern for future mechanical failure of a component left in-situ during the revision surgery further reinforce this approach [20, 53, 55].

Recurrent incontinence may also be secondary to atrophy of the underlying spongy tissue beneath the urethral cuff. Typically, patients with urethral atrophy will report a gradual recurrence of stress urinary incontinence. The diagnosis is confirmed during cystoscopy, where incomplete urethral coaptation is visualized with device cycling (with adequate fluid in the system). The treatment of incontinence secondary to urethral atrophy is centered on device revision. Surgical options for AUS revision in these cases include changing the location of the urethral cuff (moving proximally or distally), downsizing the urethral cuff, placement of a tandem urethral cuff, or revising the pressure-regulating balloon. The decision between these management options is based on the local tissue quality, location of the in-situ urethral cuff and surgeon preference. Our typical initial management is with cuff downsizing (if proximal repositioning is not possible), reserving tandem cuff placement for future revisions if needed [23, 57, 58].

65.6 Conclusions

Stress urinary incontinence is a noteworthy problem with a large impact on quality of life affecting many men, particularly those with a history of surgical or radiotherapeutic manipulation of the external urinary sphincter. The evaluation of men presenting with iatrogenic stress incontinence begins with a history and physical examination. Additional studies such as cystoscopy, pad testing, or urodynamic studies are performed as needed based on the clinical scenario. Patients with large-volume incontinence, prior radiation, or a prior failed urethral sling are likely best managed with AUS if they are appropriate surgical candidates. Excellent long-term AUS device survival and continence outcomes have been noted in many series following primary implantation.

The most common complications of AUS placement include urinary retention, scrotal hematoma, infections, erosions, and recurrent urinary incontinence. Appropriate patient counseling regarding the available management options, expected postoperative convalescence, surgical risks and device outcomes are crucial when considering surgery for stress urinary incontinence.

Key Summary Points

- Stress urinary incontinence is a noteworthy problem with a large impact on quality of life affecting many men, particularly those with a history of surgical or radiotherapeutic manipulation of the external urinary sphincter.
- Despite variation between studies secondary to a lack of standard methods for reporting the degree of incontinence or criteria to define “success,” the current literature consistently demonstrates high long-term success rates for primary AUS implantation. In our own retrospective series of primary AUS implantations performed at our institution, we found 5, 10 and 15 years device survival

rates of 74%, 57% and 41%, respectively.

- Several reports have demonstrated, albeit in small series, excellent outcomes for AUS placement after a previous urethral sling. In cases of failed urethral sling placement, our preference is to place an AUS.
- The studies available in the current literature evaluating the association of radiotherapy and device survival have met with conflicting results. A recent analysis of patients in our practice who underwent primary AUS placement found no association between pelvic radiation therapy with prostatectomy and increased risk of device infection or erosion when compared to prostatectomy alone. Patients treated with pelvic radiation therapy should not be excluded from receiving an AUS solely based on this comorbidity.

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Surgical Management of Neurogenic Lower Urinary Tract Dysfunction in Men with Spinal Cord Injury

Joshua D. Roth and Sean P. Elliott

66.1 Introduction and Nature of the Problem

Neurogenic lower urinary tract dysfunction (nLUTD) is highly prevalent after spinal cord injury (SCI) and significantly impairs quality of life [1, 2]. Although treatment is usually non-surgical, those with elevated bladder pressures or refractory urinary incontinence may require more aggressive surgical management [2].

The goals of nLUTD management include (1) a highly compliant, low pressure bladder to protect the upper urinary tracts and store adequate volumes of urine and (2) predictable and controlled urine emptying without urinary incontinence [3].

The mainstay of nLUTD management is clean intermittent catheterization (CIC) plus medical management of bladder hyperreflexia using anticholinergics and/or intradetrusor onabotulinumtoxin A [4–6]. In those who cannot perform CIC due to preference or physical limitation, indwelling urinary catheters are often used to maintain low bladder pressures and remain dry. However, indwelling urinary catheters are associated with complications such as urinary tract infection, urinary stones, catheter obstruction, urethral atrophy/erosion/necrosis, and fistula. Many of these

complications are worsened when catheters are sequentially upsized in reaction to pericatheter leakage [7, 8].

Surgery can add, enhance, or obviate medical therapies to help achieve the goals of nLUTD management. There are several indications for surgical intervention (Table 66.1). This article will not explore the surgical interventions of intradetrusor onabotulinumtoxin A injection, urethral bulking agents, suprapubic catheter placement, or sacral/peripheral nerve stimulation. Instead, we will focus on reconstructive surgery for the lower urinary tract.

66.2 Surgery to Reduce Bladder Pressure: Augmentation Cystoplasty

66.2.1 Indications

In individuals with SCI and nLUTD who have failed medical and intravesical therapies, augmentation cystoplasty (AC) can be performed to create a larger reservoir that stores urine at low pressure and helps achieve continence, while protecting the upper urinary tract. In those without a competent urinary sphincter, a combination of AC and bladder outlet procedures can be used to achieve continence in those patients who are willing to accept the required lifelong maintenance.

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Table 66.1 Surgical Indications for patients with nLUTD

Indication	Sequela if untreated	Goals for surgery	Surgical intervention(s)
Failure of maximal medical therapy for elevated bladder pressure	↑ Detrusor pressure ↓ Renal function Recurrent infection	↓ Detrusor pressure	1. SPC 2. Augment ± CCC 3. Urinary diversion
Inability to perform or aversion to urethral CIC	Urinary retention ↑ Detrusor pressure ↓ Renal function	Facilitate CIC Maintain or ↓ detrusor pressure	1. SPC 2. CCC ± augment 3. Urinary diversion
Urinary incontinence due to low outlet resistance	Personal/social embarrassment Skin maceration/breakdown	Achieve continence	1. SPC 2. Sling 3. AUS 4. BNR
Complications from chronic, indwelling catheters	Pubovesical fistula Urethral erosion Bladder perforation End-stage, contracted bladder	Repair and diversion	1. Urinary diversion 2. Cystectomy ± pubectomy

Abbreviations: *Augment* augmentation cystoplasty, *AUS* artificial urinary sphincter, *BNR* bladder neck reconstruction, *CCC* continent catheterizable channel, *CIC* clean intermittent catheterization, *nLUTD* neurologic urinary tract dysfunction, *SPC* suprapubic cystostomy

While initially described over a century ago [9], AC with the use of ileum was refined by Goodwin in the 1950s [10, 11], and continued to be refined into the 1980s, when the detubularized and reconfigured clam enterocystoplasty that is commonly used now was first described [12]. AC became common after Lapides introduced CIC as a safe and effective method of bladder emptying in the 1970s [13]. Recently, the rates of AC have decreased after the Food and Drug Administration approved intradetrusor onabotulinumtoxin A for the treatment of urinary incontinence secondary to detrusor overactivity in 2011 [14]. Indications for AC in patients with SCI and acquired nLUTD include (1) elevated detrusor leak point pressures, loss of bladder compliance and refractory detrusor overactivity or (2) reduced bladder capacity requiring an indwelling catheter or prohibitively frequent CIC.

66.2.2 Contraindications

Appropriate patient selection is paramount when deciding to perform AC. In addition to the relative contraindications of ensuring proper patient selection, several medical conditions contraindicate performing AC. Compromised bowel, either from inflammatory bowel disease or radiation enteritis, place patients at risk for enterovesicular or entero-

entero fistulae. Patients with significant prior small bowel resection or those at risk for functional short bowel syndrome due to chronic intestinal pseudo-obstruction syndrome, refractory sprue, radiation enteritis, or congenital villus atrophy may experience short bowel syndrome after AC, which occurs when there is less than 200 cm of healthy residual bowel [15]. Further, bowel resection may potentiate renal and hepatic disease in those with baseline insufficiency. Advanced renal failure is also a relative contraindication for bladder augmentation due to the risk of metabolic derangement that occurs from the absorption of urine from the augmented bowel segment [16, 17]; a typical cutoff for serum Creatinine is 2.0 ng/dL. Those with cognitive impairment, drug or alcohol dependence all present a contraindication to AC as they are unlikely to adhere to their CIC schedule, which places them at risk for perforation of the augmented bladder [18]. Exceptions can be made for those with cognitive impairment if they have reliable healthcare aids or family members to perform CIC.

66.2.3 Approach and Technique

The technical aspects for open AC date back for more than a century and remain largely unchanged [9, 11, 12, 19–22]. Recently, there have been sev-

eral publications describing a minimally invasive approach to AC utilizing similar principles to open surgical procedures [23–25]. The use of small bowel, colonic and gastric segments have all described [26]. The use of gastric segments, however, have essentially been abandoned due to the development of hematuria-dysuria syndrome, refractory metabolic alkalosis, and increased risk of aggressive neoplasia compared to other forms of AC [27–29].

Detubularized ileum is currently the preferred bowel segment for AC [12, 30–32]. Ileum is generally mobile and the resection and anastomosis of ileum is familiar to most urologists. In cases where the ileum is not suitable for AC, ileocolic or sigmoid AC can be performed. The reconstructive urologist should become familiar with using large bowel in AC as it carries many advantages in patients with nLUTDS: treating chronic constipation by improving colon transit time via resecting a dilated and redundant sigmoid colon and avoiding malabsorption problems that occur with resection of the terminal ileum.

66.2.4 Outcomes and Complications

Following AC, patients can expect durable increases in bladder storage capacity with concomitant reductions in detrusor pressures and improvement in incontinence based on multiple studies with intermediate and long-term follow up [30–35]. Complications are well documented and highly variable (Table 66.2). While aggressive, malignancy is rare and not increased following AC; the increased risk of bladder cancer in this population is now believed to be due to the neurogenic bladder itself [36].

Table 66.2 Complications after augmentation cystoplasty

Complication	Frequency (%)
Acid-base/electrolyte disturbance	<5% [16, 17]
Vitamin B12 deficiency	33–44% [37, 38]
Urinary stones	9–44% [39–41]
Perforation	6–13% [42–44]
Malignancy	1–4.5% [36, 45–47]

66.3 Surgeries to Allow Ease of Catheterization: Continent Catheterizable Channels

66.3.1 Indications

CIC, popularized by Lapides et al., allowed for the development of AC and continent urinary reservoirs by creating an effective means to drain urine [13, 48]. Continent catheterizable channels (CCC) are created to facilitate ease of intermittent catheterization, which can be technically challenging in men with quadriplegia or a large body habitus, especially in a wheelchair. In patients with decent residual hand function, a CCC exiting the abdominal wall can improve independence and allow for a more discrete bladder emptying method by simplifying CIC. There are multiple factors, including comorbidities, anatomy, and occupational factors, that must be considered when counseling patients regarding CCCs (Fig. 66.1).

66.3.2 Contraindications

Contraindications to CCC are similar to those for AC (Table 66.2), except in cases where the appendix is able to be used for the CCC as no bowel resection is required.

66.3.3 Approach and Technique

CCCs can be categorized in terms of their continence mechanism (Fig. 66.2). Tunneled, or “flap valve” channels rely on the Mitrofanoff principle, where the CCC is tunneled through the detrusor muscle of the bladder – as the bladder fills continence is enhanced because the CCC is compressed between the bladder mucosa and muscle [49]. CCC can be created from appendix (appendicovesicostomy) or a segment of retubularized ileum (Yang-Monti ileovesicostomy or Casale procedure/spiral Monti) [49–52].

Alternatively, nipple valves maintain continence via circumferential coaptation. The ileoce-

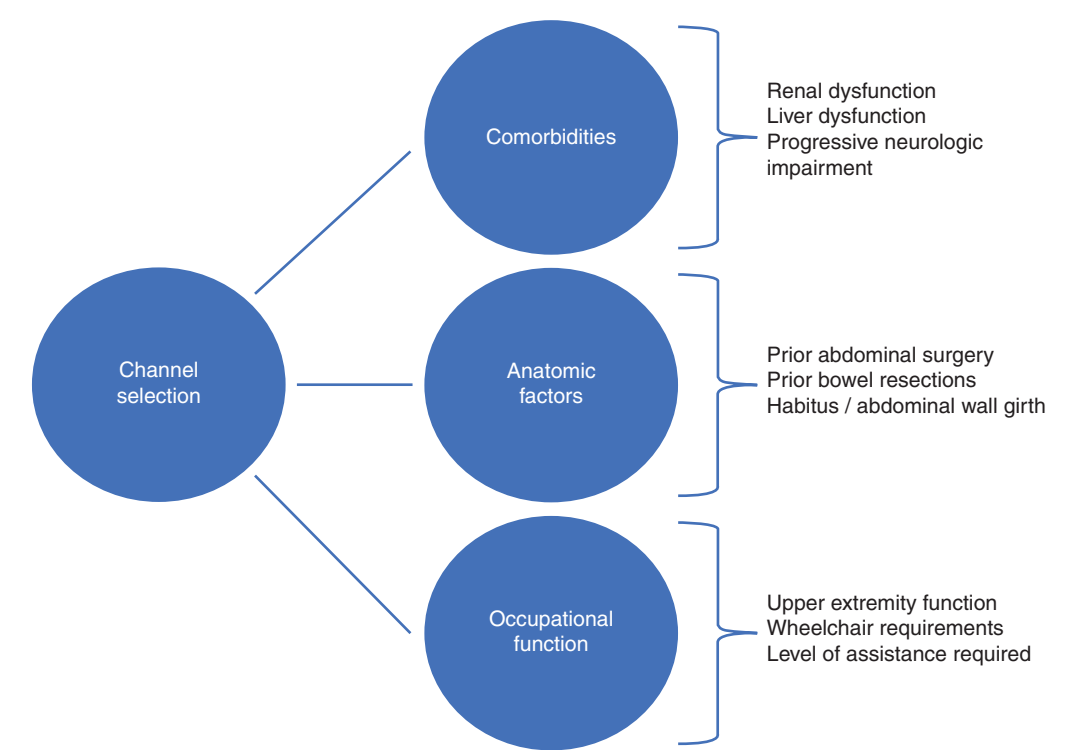


Fig. 66.1 Patient selection criteria for continent catheterizable channel

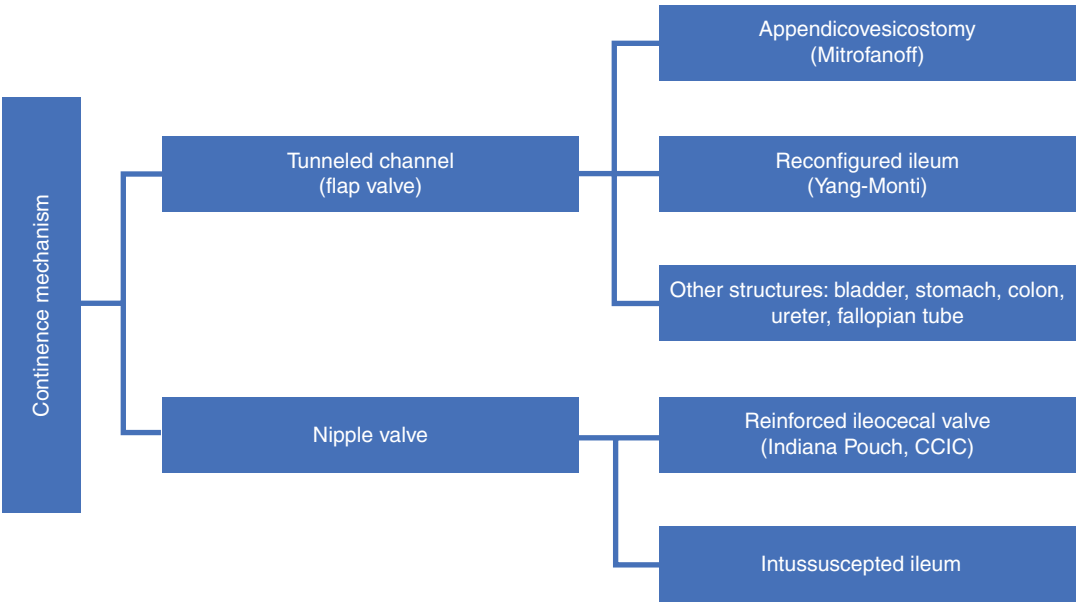


Fig. 66.2 Continent catheterizable channel choices, stratified by continence mechanism. CCIC, continent catheterizable ileocecocystoplasty

cal valve is a naturally occurring nipple valve and is used commonly in an “Indiana” pouch or a continent cutaneous ileocecal cystoplasty (CCIC) along with tapering of the efferent limb of ileum to create the CCC [53, 54]. An alternative valve is the intussuscepted ilea nipple valve, as utilized in the Kock pouch; however, it is seldom used due to technical complexity, difficulty to reproduce and suboptimal outcomes [55, 56].

66.3.3.1 Tunneled Channel and Flap Valve: Mitrofanoff Appendicovesicostomy

Originally introduced in 1980, the Mitrofanoff appendicovesicostomy remains a popular option to create a CCC in children [49, 57]. This procedure is performed by tunneling the appendix into the native bladder, either intravesically or extravesically, or into the tenia coli in a colonic AC. The appendix works well as a CCC because its lumen diameter obviates the tapering the bowel for catheterization; further, the appendix wall is resilient and withstands frequent catheterization. The appendicovesicostomy is most commonly performed through a midline or Pfannensteil incision; laparoscopic or robotic-assisted approaches have been described but are technically challenging in adults [58–62].

There are special considerations that need to be made when considering performing an appendicovesicostomy in adults. Adults have longer torsos and thicker abdominal walls; the surgeon must ensure that the appendix is long enough to tunnel into the bladder and reach the abdominal wall. Whereas a 4 to 6 cm appendix can make a suitable CCC in children, an 8–12 cm appendix is needed in adults. Greater length can be achieved by including a small cuff of cecum on the appendix. In cases with restrictive mesenteric length, the ascending colon can be mobilized [61]. The umbilicus is often selected for the stoma location in children because it is discrete. In adults, the skin of the umbilicus is chronically inflamed and thickened; for this reason, we prefer not to use it for maturing our stoma. We routinely excise the umbilical base in adults so the channel can be matured to healthier superficial umbilical skin. The creation of a rosebud stoma



Fig. 66.3 Rosebud appearance of catheterizable channel after excisions of umbilical base

is often used in adults to minimize stomal stenosis (Fig. 66.3), which is different from children where a Y-V flap of abdominal wall skin is often used to mature the stoma and prevent stomal stenosis [61].

66.3.3.2 Tunneled Channel and Flap Valve: Reconfigured Ileum (Yang-Monti)

The appendix may not be usable for a CCC if it is absent, retrocecal, short, or has a restricted mesentery. For these cases, reconfigured ileum was popularized as a CCC by Yang in 1993 and Monti in 1997 [50, 51]. A Yang-Monti channel is created by isolating a 2 cm piece of ileum that is first detubularized (Fig. 66.4a), then retubularized transversely along its antimesenteric border over a catheter (Fig. 66.4b). Imbricating sutures are then placed as needed to achieve an appropriate channel diameter (Fig. 66.4c). A typical Yang-Monti channel is approximately 6 cm, which often is not a suitable length in adults. Thus, in adults, a double Yang-Monti channel can be created where two separate channels are made and then sutured together [51]. Alternatively, a single piece of bowel can be used to make a long CCC, as described by Casale in 1999 [52]. A 3.5 cm segment of ileum is harvested and the ileal segment is divided close to the mesentery and a Z-shaped incision is made that begins close to the mesentery on one side and ends close to the mesentery on the opposite side. The segment of

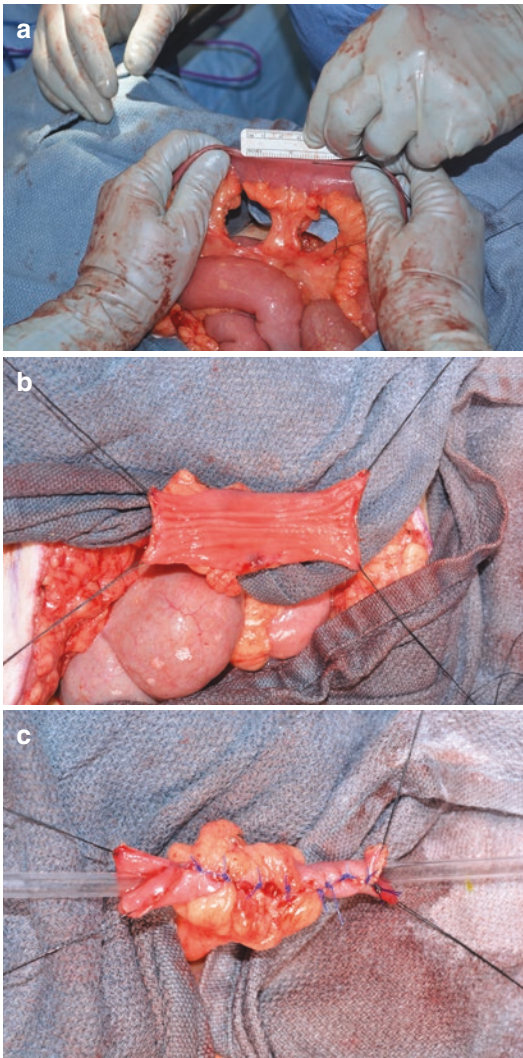


Fig. 66.4 Yang-Monti channel. (a) Isolation of small bowel. (b) Antimesenteric detubularization. (c) Transversely retubularized ileal segment

bowel is then reconfigured over a catheter to create a 10–14 cm channel [52].

66.3.3.3 Nipple Valve: Tapered Ileal Channel

The ileocecal valve is a natural continence mechanism. Its use was first described in the 1950s [63], with its principles later adapted for use in the Kock pouch [55], and popularized in 1987 with the description of the Indiana Pouch [53]. In the early 1990s, the principles of the Indiana Pouch were extrapolated when Sarosdy described reconfiguring the ileocecal segment for use as an AC and CCC [54]. Sarosdy’s continent catheterizable ileoceco-cystoplasty (CCIC) provides similar rates of continence, stomal stenosis and has similar revision rates compared to other forms of CCC (Table 66.3).

The CCIC can be performed either through an open or a hybrid laparoscopic-open approach. In order to ensure a tension-free anastomosis, it is important to mobilize the ascending colon around the hepatic flexure. This degree of mobilization requires an incision above the umbilicus through an open approach but can be accomplished through a Pfannenstiel incision with a hand-assist port. When performing a laparoscopic mobilization of the colon for CCIC, a 12-mm camera port is placed through the umbilicus, which later serves as the stoma site for the CCC, and a 5-mm assist port is placed on the left side of the abdomen, a hand-breadth cephalad to the 12-mm port (Fig. 66.5).

It is important to adequately mobilize the ascending colon so that the bowel anastomosis is tension free. One can be sure the colon is adequately mobilized when the duodenum, kidney

Table 66.3 Outcomes and complications of continent catheterizable channels

Procedure	Continence rates (%)	Stomal stenosis (%)	Revision rate (%)
Nipple valve	>95 [62, 64, 65]	5–10 [62, 64–66]	5–20 [62, 64–66]
Appendicovesicostomy			5–20
Reconfigured ileum			10–20
Single Yang-Monti			
Spiral Yang-Monti			
Tapered ileum	>95 [67]	3–9 [67, 68]	5–13 [61, 68]
Continent cutaneous ileoceco-cystoplasty			

Fig. 66.5 Port placement for hand-assisted laparoscopic mobilization of the ascending colon

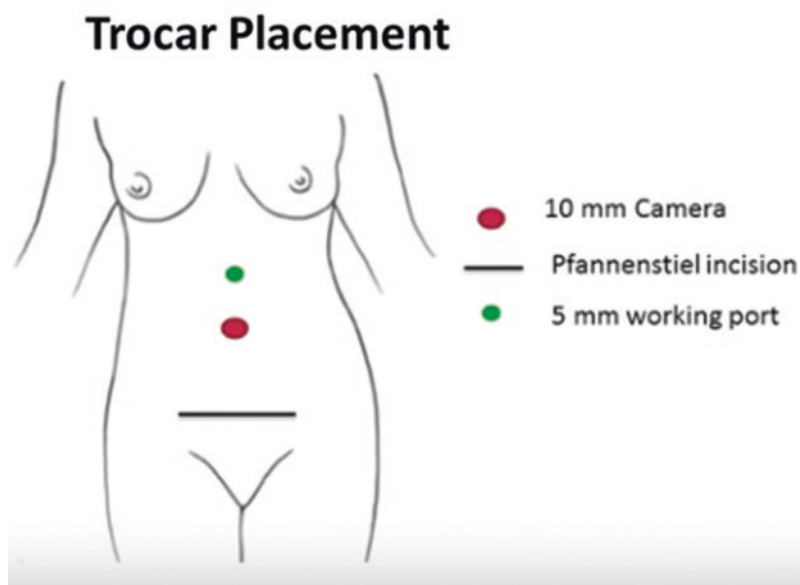


Fig. 66.6 “Landing zone” highlighting landmarks for mobilization of ascending colon. GB gallbladder, IVC inferior vena cava

and inferior vena cava are well visualized (Fig. 66.6). After the colonic mobilization is completed, the remainder of the procedure is performed in an open fashion through the Pfannenstiel incision. This is advantageous as ventral hernias are rare with a Pfannenstiel as compared to midline incisions, a risk that is often exacerbated by the weak abdominal walls often observed in patients with nLUTD [69, 70]. Due to the proximity to the incision, there can be higher rates of parastomal hernias when umbilical channels are created in the setting of midline laporotomies compared to Pfannenstiel incisions. However, Pfannenstiel incisions are only employed for virgin or benign operated abdomens. In anyone with

multiple prior surgeries, hand-assisted laparoscopic right colon mobilization is attempted through a lower midline incision in an attempt to avoid an extended laparotomy around the umbilicus if the mobilization can be completed in a minimally invasive manner. If a midline laparotomy is used, it is recommended to place the stoma in a paramedian location so that it will not be involved if a ventral hernia develops.

The remainder of the procedure is described elsewhere [61]. Approximately 10 cm segments of cecum and ileum are harvested. The cecum is detubularized and refashioned, and then the distal ileum is tapered over a 14F catheter with a GIA-100 stapler (3.8 mm staple width) (Fig. 66.7). Next, a bladder incision is made sagittally from the bladder neck to the trigone and the cecal segment is anastomosed in this location widely to prevent hourglass deformity. Once complete, the ileal limb is matured through the umbilicus if a Pfannenstiel incision was used or through a paramedian location through the rectus muscle if a midline laparotomy was used. The tapered ileum limb exits from the dome of the AC and provides a CCC of about 8 cm, compared with 12–14 cm with a double or spiral Monti. This shorter length is often preferable as it leads to fewer catheterization problems.

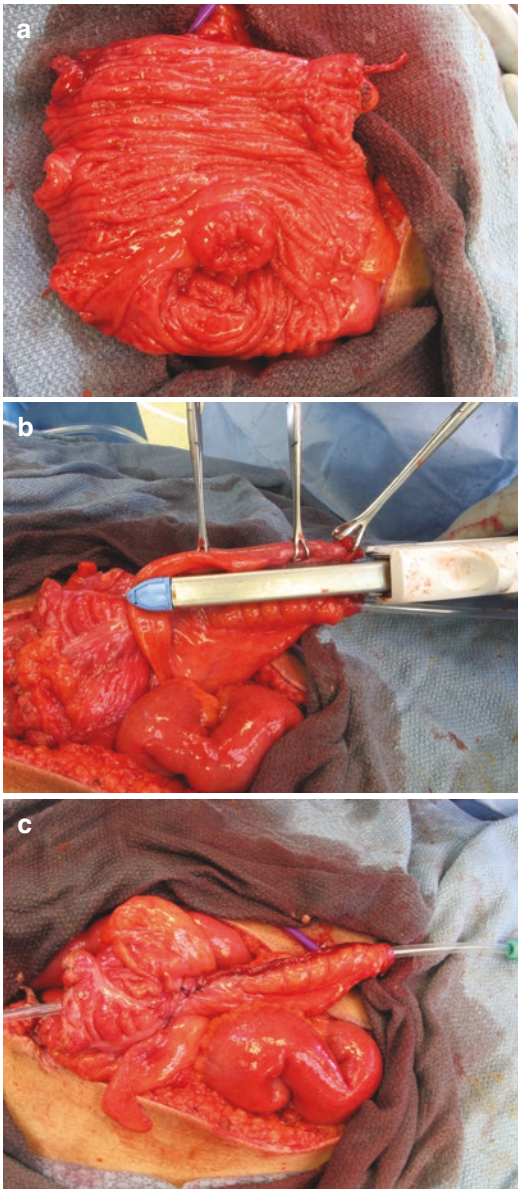


Fig. 66.7 (a) Detubularized cecum with ileocecal nipple valve. (b) Tapering of terminal ileum with a GIA-100 stapler. (c) Reinforced channel and ileocecal valve

66.3.4 Outcomes and Complications

There are limited studies with adequate follow up in patients who have undergone CCIC, making it hard to draw conclusions about its long-term efficacy. However, known outcomes in patients with nipple valve CCC are currently comparable to

patients with tunneled channels (Table 66.3). However, the CCIC provides distinct advantages for adults with nLUTD including the creation of a capacious cecal augment with minimal bowel resection, creation of a channel whose length is easily modifiable to ensure a better fit for all patients regardless of body habitus, and elimination of the need to create a detrusor tunnel. There are also disadvantages unique to ileocecal resection including faster colonic transit time, possible fecal incontinence, vitamin B12 deficiency and the need for a mechanical bowel preparation.

66.4 Surgery for Sphincteric Incontinence

When nLUTD results in denervation of the sphincter, stress urinary incontinence (SUI) from intrinsic sphincter deficiency (ISD) can occur. Multiple options exist to address this, including bulking agents (which is beyond the scope of this chapter), bladder neck sling, bulbar urethral sling, artificial urinary sphincter (AUS), and bladder neck closure (BNC).

66.5 Bladder Neck Sling

66.5.1 Indications

Slings are indicated in patients with ISD secondary to nLUTD. They improve continence by increasing bladder outlet resistance through direct bladder neck compression.

66.5.2 Contraindications

Slings should be avoided in SCI patients who void using Valsalva and Crede maneuvers and are unwilling or unable to perform CIC. Slings should not be placed in those with poor bladder compliance as this may destabilize a high-pressure bladder and risk upper tract deterioration, which has been shown to occur at a rate of 45–100% in children who undergo bladder neck procedures without AC [71, 72].

66.5.3 Approach and Technique

An abdominal approach is used in men to be able to place the sling between the bladder neck and the seminal vesicles [73]. This can be approached either open or robotically in a manner similar to an open or robotic radical prostatectomy. When performed in an open manner, an extraperitoneal dissection is performed to separate the endopelvic fascia. Then a plane is created posteriorly around the bladder neck and anterior to the seminal vesicles. When performed robotically, the seminal vesicles can be dissected first via a posterior approach prior to developing the space of Retzius. The endopelvic fascia is then divided, which will join the anterior and posterior dissections, allowing for sling placement.

Grafts can be synthetic mesh, autografts (rectus fascia or tensor fascia lata), allografts, or xenografts. While all are viable options, autografts offer the advantage of being readily available and cost effective. Furthermore, there is concern that a high tensioning of a synthetic sling will, over time, lead to sling erosion.

66.5.4 Outcomes and Complications

While few, series that describe outcomes for bladder neck slings in adults with nLUTD seem promising (continence rates of 83–85%). Only 8–15% of patients underwent additional procedures [73, 74].

66.6 Artificial Urinary Sphincter

66.6.1 Indications

Almost five decades after being introduced, the design of the AUS has remained relatively unchanged [75]. The typical AUS (manufactured by American Medical Systems) has three components: the cuff, the pressure regulating balloon, and the pump. In men with nLUTD, the cuff is placed around either the bladder neck or the bulbar urethra. In men who spend the majority of

time in a wheelchair there is concern about perineal erosion from sitting on the cuff. The cuff opens and closes as fluid cycles between it and the pressure regulating balloon when the scrotal pump is activated. The AUS is ideally suited for those with intrinsic sphincter deficiency, compliant bladders of sufficient storage and retained upper extremity function who void volitionally.

66.6.2 Contraindications

Contraindications for AUS include a small capacity or high-pressure bladder or inability to operate the device.

66.6.3 Approach and Technique

The surgical approach to AUS in nLUTD is dictated by cuff location: bladder neck or bulbar urethra. Cuff sizes range from 3.5 to 11 cm, with larger cuffs for the bladder neck. When selecting cuff location, the need for future urethral instrumentation, such as CIC, prolonged catheterization, or cystoscopy should be considered as urethral instrumentation across smaller bulbar urethral cuffs is associated with device erosion [76, 77]. As men with nLUTD will often require cystoscopy, larger bladder neck cuffs placed around more robust tissue minimizes the risk of device erosion and subcuff atrophy [78, 79].

The bladder neck cuff is placed transabdominally via an open or minimally invasive fashion [80]. The dissection is similar to that which was previously described for bladder neck slings. The approach to placing a bulbar cuff is well described elsewhere and will not be covered herein. The pump is placed in a sub-dartos pouch in the scrotum and the pressure regulating balloon is typically placed in either the retropubic or submuscular space, both of which can be accessed through the external inguinal ring or via a counterincision [81]. A bladder neck AUS can be placed safely at the time of AC without a significant increase in the risk of device infection [82, 83] [73].

66.6.4 Outcomes and Complications

Few studies have evaluated outcomes of AUS in adults with nLUTD. However, the continence results that have been reported seem acceptable, with 74% of patients reporting continence, or minimally leakage as evidence by nocturnal leakage only or only wearing a safety pad [84]. However, men with SCI undergoing AUS should be counseled on the high rate of revision surgery – 85% in neurogenic ISD vs. 59% in post-prostatectomy incontinence [85]. Additionally, the life span of bladder neck AUS devices are short, ranging from 4.7–6.0 years depending on the study, with fewer than 10% surviving more than 8 years [84, 86, 87]. Device erosions and infections are significant complications that require urgent device removal with repair of the urothelial defect and delayed subsequent intervention after months of healing.

66.7 Bulbar Urethral Slings

66.7.1 Indications

Bulbar urethral slings are significantly less invasive option for men with neurogenic ISD compared to bladder neck slings.

66.7.2 Contraindications

Bulbar urethral slings are designed to augment sphincteric function by repositioning the bulbo-membraneous urethra 2.5–3 cm toward the bladder neck. As slings do not replace the function of the sphincter, some consider ISD itself to be a contraindication to bulbar urethral sling placement [88]. Bulbar urethral slings are contraindicated in those who are not able to perform CIC either independently or dependently. Additionally, they should only be placed in patients with safe bladder compliance.

66.7.3 Approach and Technique

The only sling tested in patients with nLUTD is the AdVance male sling, which is a transobturator sling [89]. The mechanism of the transobturator sling is poorly understood, but is believed to work by repositioning the urethra closer to the bladder neck, which results in enhanced urethral coaptation without obstruction. However, in neurogenic patients with ISD there is likely some compression resulting in increased outlet resistance [88]. Bulbar urethral slings are placed through a standard perineal approach, which allows for quick insertion with minimal morbidity.

66.7.4 Outcomes and Complications

Bulbar urethral slings were designed for and typically placed for post-prostatectomy incontinence. However, in one series evaluating AdVance sling placement in 20 men with neurogenic ISD, 40% reported continence, 25% reported improvement in their incontinence, and 35% reported failure. Complications were low and included hematoma in 15% and challenging CIC in 15%, with one patient requiring a suprapubic catheter [89]. Given these suboptimal results, bladder neck slings should be favored over bulbar urethral slings in the neurogenic population.

66.8 Bladder Neck Closure

66.8.1 Indications

Bladder neck closure (BNC) is a “last resort” in ISD management. When performed, another option to drain the bladder must exist, either via suprapubic catheter or cutaneous stoma. A fixed, open bladder neck can be the result of the SCI itself, prior surgeries, or as sequela of chronic indwelling urethral catheters. BNC should be considered for patients with severe urinary incon-

tinence who either may not have the dexterity or support to cycle an AUS, have failed prior interventions to increase bladder outlet resistance, or have incontinence that is too severe for either an AUS or sling.

66.8.2 Contraindications

It is of the utmost importance that patients are properly selected prior to undergoing BNC, as they will lose access into their bladder through their urethra following this procedure. As such, those are unable to follow up for routine suprapubic catheter exchanges and those who are unable to perform or arrange for CIC via CCC are not candidates for BNC. When counseling patients and caregivers regarding BNC, it must be understood that a dislodged suprapubic catheter or compromised CCC constitute a medical emergency that requires prompt attention as there is no alternative route to drain the bladder. Those with prior bladder neck reconstructions or multiple prior abdominal surgeries who may not have adequate tissue for interposition are at greatest risk for failure. BNC should only be considered in those with compliant bladders, as loss of compliance may occur after isolated bladder neck procedures [71, 72].

66.8.3 Approach and Technique

BNC is typically performed transabdominally, however, transperineal BNC has been described in men [90]. Via either approach, the bladder neck must be mobilized and a plane established between the bladder and rectum. A popular modification that has been readily adopted to achieve higher continence rates involves elevating a lip of posterior bladder wall that becomes incorporated into the AC or cystorrhaphy [91]. It is important to note the location of the ureteral orifices as they can easily become incorporated into the closure or kinked or injured during posterior mobilization. If this occurs, the ureters should be reim-

planted [92]. The urethral stump should be closed in two layers and tissue interposition, either with omentum, peritoneum, human pericardium, or transverse rectus abdominus, should be strongly considered to prevent recanalization [90, 93]. This procedure is easier in younger men with a small prostate.

66.8.4 Outcomes and Complications

Patients who undergo BNC typically have severe incontinence or may have already failed other bladder neck procedures. As such, reported success rates for BNC are lower than those of other surgeries for ISD. Failure rates range from 10–20% in those undergoing transabdominal BNC due to fistula formation [90, 92, 94, 95]. Other series report success rates at 20 months of 92%, however 73% of patients required at least one additional operation to achieve continence [94].

66.9 Surgeries that Abandon the Bladder: Urinary Diversion

66.9.1 Indications

Some patients elect for urinary diversion for quality of life reasons or due to refractory symptoms. Conditions that warrant consideration of urinary diversion include urethral erosion with a devastated bladder outlet, chronic urinary tract infections in a poorly compliant bladder, non-healing decubitus ulcers in the setting of urinary incontinence, and an inability to manage indwelling or intermittent catheterization. Chronic urethral catheterization carries morbidity, such as development of a pubovesical fistula or pubic bone osteomyelitis, that requires urgent intervention. In radiated patients, chronic catheter drainage can lead to bladder perforation [8]. For these reasons, these conditions are best managed with urinary diversion, which simplifies care and enhances quality of life [64].

66.9.2 Contraindications

Urinary diversion should be avoided if the caregivers of a cognitively impaired patient report that he is likely to repeatedly pull off his stoma appliance. While not a contraindication, obesity makes the surgery technically challenging due to having a short mesentery and thick abdominal wall, which increases the risk for complications such as parastomal or ventral hernia, stomal stenosis, and difficulties managing their appliance due to a skin fold or a flush stoma.

66.9.3 Approach and Technique

When deciding to perform a urinary diversion, it is critical to decide which type of diversion will be offered to the patient and whether or not to perform cystectomy at the time of diversion. Leaving the bladder *in situ* risks pyocystitis and may require subsequent cystectomy [65–67]. Techniques for cystectomy are well-described [68, 96]. Minimally invasive approaches to simple cystectomy are increasingly used when feasible [64]. Supratrigonal cystectomy minimizes morbidity of blood loss and erectile dysfunction while offering comparable outcomes to total cystectomy [97]. In men with concomitant urethral stricture disease, total cystoprostatectomy should be performed, as prostatic and urethral secretions will have no chance to drain and pyocystitis is certain to occur. The decision to offer a continent versus incontinent diversion must take into consideration the patient's ability to catheterize and perform the necessary upkeep of their diversion.

66.9.4 Outcomes and Complications

In those patients with nLUTD who undergo urinary diversion, upper tract functional preservation is noted in more than 90% [98–100]. Multiple studies have shown improved urinary quality of life in patients with nLUTD after urinary diversion [64, 98, 99]. Simple cystectomy and urinary

diversion carries significant risk, with early and intermediate complication rates ranging from 30–70% [68, 96, 98, 101].

66.10 Conclusions

nLUTD is common following SCI. This can lead many patients to have a poorly compliant bladder with many experiencing unpredictable urinary emptying. When medical and intravesical options fail to manage nLUTD, augmentation cystoplasty remains the gold standard to create a larger volume urinary reservoir to store urine at lower pressures. To facilitate ease of catheterization, continent catheterizable channels can be created to have the patient catheterize through an abdominal wall stoma. In those with intrinsic sphincter deficiency, bulking agents, bladder neck slings, bulbar urethral slings, artificial urinary sphincter (AUS), and bladder neck closure (BNC) can all be considered to increase outlet resistance and help manage incontinence. Some patients elect for a urinary diversion to manage nLUTD.

Key Summary Points

- When medical and intravesical therapies fail, augmentation cystoplasty can be performed to create a larger reservoir that stores urine at low pressure and helps achieve continence, while protecting the upper urinary tract
- Continent catheterizable channels can be categorized in terms of their continence mechanism: tunneled/“flap valve” channels rely on tunneling through the detrusor muscle of the bladder, nipple valves (such as the ileocecal valve) maintain continence via circumferential coaptation.
- Multiple options exist to address intrinsic sphincteric deficiency, including bulking agents, bladder neck sling, bulbar urethral sling, artificial urinary sphincter, and bladder neck closure.

- Conditions that warrant consideration of urinary diversion include urethral erosion with a devastated bladder outlet, chronic urinary tract infections in a poorly compliant bladder, non-healing decubitus ulcers in the setting of urinary incontinence, and an inability to manage indwelling or intermittent catheterization.

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Part IV

Gender-Affirming Surgery

Urethral Reconstruction in Female-to-Male Gender Affirming Surgery

67

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67.1 Introduction

Female-to-male gender affirmation phalloplasty represents one of the most challenging issues in genitourethral reconstructive surgery. Although techniques and outcomes have been vastly improved during the past decades, an ideal solution that would satisfy all patients' requirements has not yet been reported. Creation of a cosmetically acceptable and functional neophallus, and a neophallic urethra that will enable voiding in standing position, are the most important surgical tasks. These goals can be achieved by metoidioplasty or total phalloplasty. Metoidioplasty is a variant of phalloplasty for female-to-male transsexuals, wherein a small neophallus is created from a hormonally enlarged clitoris, with urethral lengthening in a one-stage procedure. It results in male appearance of genitalia, with completely preserved erogenous sensation and voiding in standing position, but without the possibility for penetrative sexual intercourse. Total phalloplasty represents the creation of an adult sized neophallus using extragenital tissue, either as a pedicled

flap or a free flap. A variety of flaps have been reported for female-to-male gender affirming phalloplasty. However, none of these methods can accomplish all goals of phalloplasty: satisfactory cosmetic appearance, sufficiently large size for safe implantation of penile prosthesis to enable penetration, preserved erogenous sensation, and a competent neophallic urethra with the meatus at the top of the neoglans [1, 2].

Neophallic urethroplasty remains a huge reconstructive challenge. Either as a part of metoidioplasty or total phalloplasty, a wide spectrum of tissues and techniques are used to create a very long and functional neourethra from the native meatus to the top of the neophallus. The technique of urethroplasty generally depends on the type of phalloplasty. Neourethra can be created using a “tube-within-a-tube” principle, as in radial forearm free flap (RFFF) phalloplasty. Vascularized genital flaps (clitoral skin, labia minora, vaginal mucosa), free flaps (RFFF, gracilis flap, ulnar flap) and grafts (skin, buccal mucosa) can be used for single-stage or staged urethroplasty [3]. Despite recently improved techniques, complication rates remain high. The most common complications, urethral fistula and stricture, are reported in 10–90% of cases, with the overall urethral complication rate of 40% [4]. Urethral complications were found to be higher in the transmale popula-

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tion compared to the cismale population (39.4% vs. 24.8%) [4]. We are still searching for ideal tissue for urethral reconstruction that will guarantee a successful outcome. Tissue engineering could prove promising, but there are still many technical and bioethical issues to be resolved [5].

67.2 Surgical Options for Female-to-Male Gender Affirming Phalloplasty

There are two surgical options for female-to-male gender affirming neophalloplasty – metoidioplasty and total phalloplasty. Metoidioplasty is a variant of phalloplasty for transsexuals who wish to avoid complex, staged procedures. It is established as a one-stage procedure in which a neophallus is created from a hormonally enlarged clitoris, and urethra is lengthened to the top of the glans, resulting in male appearance of genitalia, voiding in standing position and completely preserved erogenous sensation. The main disadvantage is a small penis, which does not allow penetration [6]. Phalloplasty, or surgical construction of an adult size penis, still represents one of the most difficult surgical procedures in genital reconstructive surgery. Since the original report on penile reconstruction, many authors reported their experience with different variants of local flaps for neophalloplasty, generally based on the inferior epigastric vessels [7]. Since then, different microsurgical free flaps have been developed and are regularly used in female-to-male gender affirmation surgery. Although phalloplasty techniques have improved in many aspects, they still have many drawbacks, and neither is considered superior to others. Extensive scarring of the donor area, absence of erogenous sensitivity and common urethral complications make these multi-staged procedures unacceptable for many transsexuals. The choice of a specific surgical technique mostly depends on the patient's desires and expectations. However, it is the surgeon's duty to inform the patient about all the advantages and disadvantages, as well as all possible complications after surgical procedure, their severity and management.

Voiding in standing position is one of the main goals in female-to-male gender affirmation surgery, and it requires a functional neophallic urethra. To achieve this goal, a complex urethroplasty has to be performed. It includes the creation of a competent neophallic part and a funnel-shaped bulbar part that will bridge the native female meatus and the neophallic urethra. This funnel part of the urethra and anastomosis with the native meatus has a predilection for fistula and stricture formation, due to the high pressure and relative obstruction of the urinary stream at this point. This is why additional support with well-vascularized tissue is preferable in all cases [3, 8]. Many techniques and materials, genital and extragenital, have been used in order to achieve a successful outcome. Usually, the type of phalloplasty determines the type of urethral reconstruction. There are some general principles though, for the creation of the neourethra in transgender. It is possible to create it in the first stage, using a “tube-in-a-tube” technique in total phalloplasty, or combined flap and graft technique in metoidioplasty. Another option is to perform a staged urethroplasty, based on the Johanson principle [9]. However, lack of spongiosal and supportive tissue, frequent urethral complications and common failure to achieve good voiding stream while standing, make urethral lengthening the biggest reconstructive challenge in female-to-male gender affirmation phalloplasty.

67.2.1 Metoidioplasty

The possibility of using the clitoris for penile substitution in female-to-male transsexuals was originally reported in 1973 [10]. Since then, the techniques have been greatly improved, defining this procedure as metoidioplasty, the term derived from the Greek words ‘meta’ – ‘toward’ and ‘oidion’ – ‘male genitalia’. Metoidioplasty is a one-stage procedure wherein a hormonally enlarged clitoris is used to create a small penis (Fig. 67.1a). Crucial steps of the procedure are maximal straightening and lengthening of the clitoris by division of suspensory clitoral ligaments and short urethral plate; urethral lengthening from the native meatus to the top of the neophallus to enable voiding in standing posi-



Fig. 67.1 Metoidioplasty technique (combined graft and flap urethroplasty). **(a)** Preoperative appearance. Clitoris is hormonally enlarged; **(b)** The short urethral plate is divided, creating a gap. This maneuver is necessary to straighten and lengthen the clitoris. Buccal mucosa graft is placed and quilted to cover the gap. Flap is harvested from the right labia minora, to be joined with buccal mucosa graft; **(c)**

Bulbar part of the neourethra is formed by joining the periurethral tissue and the proximal part of the urethral plate. The right labia minora flap is joined with a buccal mucosa graft to create the penile neourethra. Distal part of the urethral plate is tubularized creating the distal neourethra; **(d)** Appearance after metoidioplasty. Two testicular implants are inserted into the scrotum created from both labia majora

tion; reconstruction of the penile shaft skin, scrotum and perineum [11].

67.2.1.1 Urethral Lengthening in Metoidioplasty

Urethroplasty presents the most difficult part of one-stage metoidioplasty. Originally, the urethral plate was left intact and the penis was short and curved [12]. In order to improve outcomes and

prevent complications, modifications of urethroplasty were reported [13]. A very long flap of anterior vaginal wall (5–7.5 cm) was used to create bulbar urethra. Additional support was provided by one labia minora flap, used to cover suture lines. Penile neourethra was created from a labia minora flap and the urethral plate, which was divided at the level of the female urethral opening. As the course of dissection was from

proximal to distal, it could compromise the vascularization of the mobilized urethral plate. The same authors reported long-term results of this technique, with complication rate of 85% [14]. They stated that an average of 2.6 procedures per patient were performed in their series to complete genital reconstruction.

There are certain issues that led to significant improvements in urethral lengthening in metoidioplasty. New general principles of urethroplasty, introduction of buccal mucosa as the best material in reconstruction of the urethra, improved knowledge on clitoral anatomy and neurophysiology, as well as rich experience in gender affirmation surgery and severe hypospadias repair, led us to establish the current, one-stage metoidioplasty [15–18]. Advanced urethroplasty with voiding while standing is possible with simultaneous use of buccal mucosa graft and genital flaps, providing lengthening of the native female urethra to reach the tip of the glans, as in males. Masculine appearance of the external genitalia is further enhanced by scrotoplasty and the insertion of two testicular implants. This approach was first reported in 2009, with the main advantage of being a one-stage procedure: removal of the vaginal mucosa, metoidioplasty, and the creation of the entire neourethra and scrotum [19].

In considering metoidioplasty, it is important to recognize all similarities between male and female anatomy. The clitoris, like the penis, is composed of two paired corporal bodies, a clitoral corona, and a dorsal neurovascular bundle. Unlike in males, the ventral portion of the clitoris is made up of a short, wide urethral plate. In order to straighten and lengthen the clitoris as much as possible, dorsal suspensory ligaments need to be completely detached from the bone. Also, the wide and short urethral plate is carefully dissected from the clitoral bodies and divided at the level of glanular corona, additionally lengthening the clitoris but creating a urethral plate defect. Urethral lengthening includes reconstruction of bulbar, penile and glandial urethra [17].

Bulbar Neourethra

Urethroplasty starts with the reconstruction of the bulbar part. One of the main advantages of

this technique is the simultaneous removal of the vaginal mucosa and use of periurethral mucosa in creation of the bulbar urethra. Periurethral tissue proved to be better supportive material compared to the previously used vaginal flap, in terms of postoperative complications [2]. The bulbar urethra suffers the highest urinary stream pressure and therefore represents a high-risk point for postoperative fistula formation. The joining of the clitoral bulbs over the neourethra and the additional covering with vascularized surrounding tissue is considered a key for successful fistula prevention at the place of anastomosis with native female urethral orifice.

Penile Neourethra

Further urethral lengthening is performed using a buccal mucosa or skin graft and vascularized genital skin flaps [20, 21]. Buccal mucosa graft has become the gold standard material in urethral reconstruction, especially due to its' histological attributes. Graft harvesting is a safe procedure without morbidity of the donor site [15, 22]. The graft is prepared and sutured to cover the defect left after the division of the short urethral plate (Fig. 67.1b). Split-thickness skin graft can be used as an alternative, harvested from labia minora or other genital area. Quilting of the graft to the corporeal bodies is very important for better survival. Urethral reconstruction is completed either by using a longitudinal dorsal clitoral skin flap button-holed ventrally, or a flap harvested from the inner surface of the labia minora. Labial flap combined with buccal mucosa graft is reported as the best option, resulting in a complication rate lower than 7% [20]. Either skin or labial flap is joined with buccal mucosa graft over a 10–12 Fr catheter to form penile neourethra (Fig. 67.1c). In both cases, all suture lines are covered with well vascularized tissue to prevent fistula formation.

Glandial Neourethra

Glans wings are mobilized like in hypospadias repair [16]. Distal part of the urethral plate and glans wings are used to form glandial neourethra and lengthen the urethra to the top of the neophallus. Penile shaft is reconstructed using the

remaining clitoral and labial skin. Labia majora are joined in midline to create the scrotal sac, and two silicone testicular implants are inserted (Fig. 67.1d).

In selected cases with well developed urethral plate, urethral lengthening can be performed by simple tubularization of the wide plate over a catheter. The choice of this procedure is based on excellent width and extreme mobility of the urethral plate that enables tubularization urethroplasty without affecting neophallic length (Fig. 67.2a–d).

Perioperative Care

Suprapubic tube is inserted into the bladder for urine derivation, and 10–12 Fr catheter is left in the neourethra as a urethral stent. Broad spectrum antibiotics and anticholinergic drugs are prescribed while the catheter is in place. Urethral stent is removed 10 days after surgery, and neourethra irrigated with 5 ml of saline every day until beginning of voiding. Patient starts to void 3 weeks after surgery, and suprapubic tube is removed safely the next day.

This single-stage metoidioplasty has good aesthetical and functional outcomes, according to

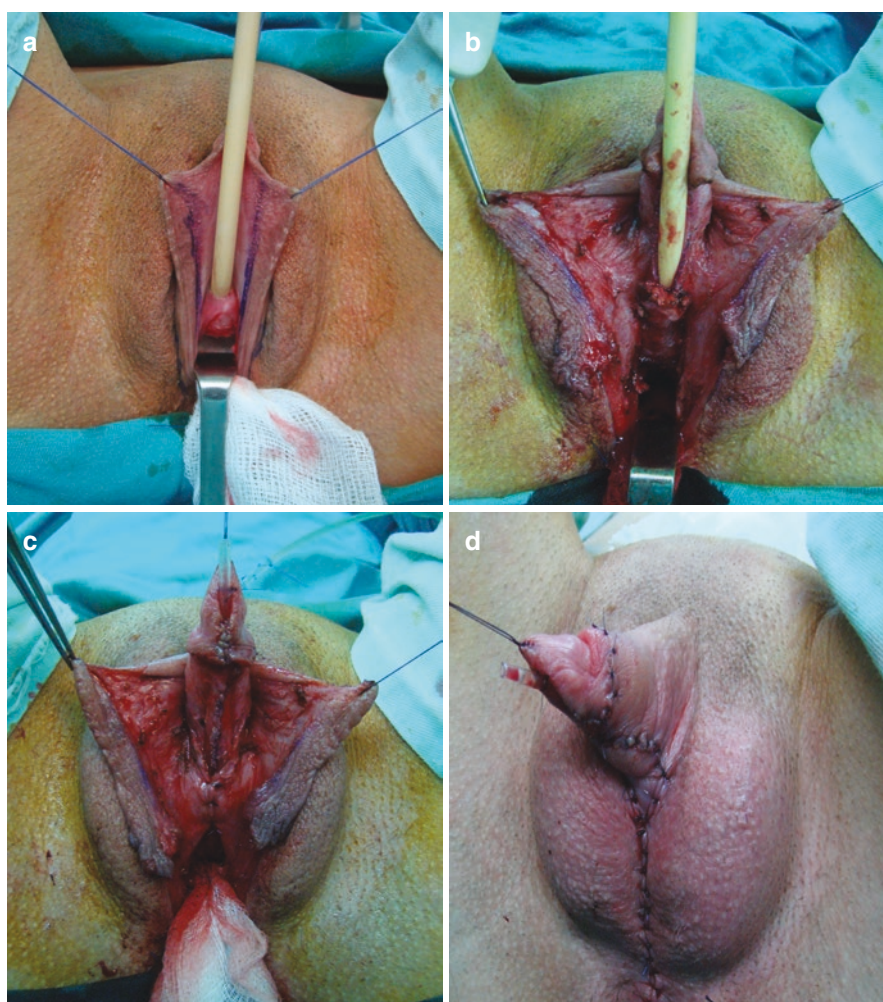


Fig. 67.2 Metoidioplasty technique (urethral plate tubularisation). (a) Preoperative appearance. Urethral plate is wide and well developed; (b) Bulbar urethra is created using a well-vascularized vaginal flap and proximal urethral plate; (c) Urethral plate is tubularized to create penile

and glandial neourethra. Proximal neourethra is covered with surrounding tissue to prevent postoperative fistula; (d) Outcome after metoidioplasty. Scrotum is formed by joining labia majora, and testicular implants are placed

patients' evaluation. Reconstruction of the neourethra enables voiding while standing in majority of reported cases. Postoperative complications related to urethroplasty can be minor (dribbling, spraying) and major (urethral fistula and stricture). Urethral fistula occurs in 7–25% of all reported cases in the long-term, and is repaired by excision of the fistula and overlaying with available local vascularized flaps. Anastomotic or buccal mucosa graft urethroplasty is performed for urethral stricture repair [18–20].

67.2.2 Total Phalloplasty

Phallic reconstruction in male transsexuals should ideally create an aesthetically pleasing phallus with sufficient length for vaginal penetration, which has tactile and erogenous sensibility, enables voiding in standing position and with acceptable donor site morbidity. A variety of neophalloplasty techniques are described, using pedicled vascularized flaps or free flaps with microvascular anastomosis. The radial forearm free flap (RFFF) is the gold standard technique in female-to-male gender affirmation phalloplasty. Other frequently used flaps include: pedicled or free anterolateral thigh (ALT) flap, musculocutaneous latissimus dorsi (MLD) free flap, abdominally based flaps and osteocutaneous fibula free flap.

67.2.2.1 Radial Forearm Free Flap (RFFF) Phalloplasty

The fasciocutaneous RFF flap was originally described for the release of cervical skin contracture after burns, but nowadays is most widely used flap for penile reconstruction. This flap enables creation of an adult-sized, sensate neophallus and voiding while standing in a single-stage surgery. Penetrative sexual intercourse is achieved if the flap is used as an osteocutaneous flap, or if a penile prosthesis can be implanted at a later stage [23].

The classical approach for RFFF phalloplasty includes simultaneous work of three teams: gynecology, urology and plastic surgeons' team. The fasciocutaneous forearm flap is harvested from

the non-dominant forearm, measuring approximately 14–18 cm in length and 14–16 cm in girth. If an osteocutaneous flap is harvested, not more than one third of the radius diameter is used with soft tissues. The flap is tubularized while connected to the neurovascular pedicle, then transferred to the pubic area and fixed in the proper position. Microvascular anastomosis is performed between radial artery and inferior epigastric artery or femoral artery; as well as cephalic and great saphenous veins. Eventually, a second venous anastomosis can be performed between a deeper radial concomitant vein and the great saphenous vein. The medial and lateral antebrachial nerves are anastomosed to the ilioinguinal or genitofemoral nerve, as well as dorsal clitoral nerve, in order to allow for neophallus sensation. The forearm defect is covered with full-thickness or split-thickness skin grafts [24]. Still, unsightly appearance of the donor area, insufficient volume of the neophallus for safe insertion of two cylinders of penile implant, and high incidence of urological complications, are important disadvantages of RFFF phalloplasty. Urethral reconstruction in RFFF phalloplasty is performed using “tube-in-a-tube” technique, or two-staged neourethra prelamination technique.

“Tube-in-a-Tube” Urethroplasty

This urethroplasty technique was originally described in radial forearm flap phalloplasty, and used afterwards in groin flap and anterolateral thigh flap phalloplasty [25–27]. It includes the design of an additional part of the flap that is tubularized over a 14 Fr catheter by inverted skin tubing to approximate free skin edges and make the urethral lining. The subcutaneous sutures are placed without tension, minimizing the exposure of suture materials in the neourethral lumen. A penile flap is wrapped around the neourethra and sutured to skin edges to create the penile shaft. However, additional tissue is necessary to cover the gap between the neophallic and native urethra and prevent possible complications. A vaginal flap and labia minora flap are used to create this bulbar, funnel-shaped part of the neourethra and extend the channel to the top of the neophallus. A wide-based vaginal flap is harvested from the

anterior vaginal wall, containing the mucosa and muscle of the vagina. Both labia minora flaps are raised as well, joined and anastomosed with the vaginal flap in a funnel-shaped fashion. Suture lines are covered with an additional layer of available, well-vascularized local tissue. Another option is to use combined wide urethral plate and labia minora flap, in selected cases. A suprapubic catheter is inserted for urine derivation. Urethral catheter is removed 2 weeks after surgery. After that, the patient starts with voiding. Suprapubic catheter is removed once the patient is able to void without significant residual volume. Urethral fistula and strictures occurred in more than 40% of cases, but the incidence of complications has been reduced recently due to refinements of the technique [4, 23, 28].

67.2.2.2 Anterolateral Thigh (ALT) Flap Phalloplasty

Perforator flaps have recently become very popular for neophallic reconstruction, due to evident benefits: great amount of favorable tissue, easier microsurgical procedure, better appearance of the donor area. Anterolateral thigh flap is a frequently used perforator flap, both as a free flap and pedicled flap. It is nourished by the descending branch of the lateral circumflex femoral artery. Pedicle length and position are of utmost importance in the planning of pedicled flap phalloplasty. Since perforator anatomy is not predictable, a detailed preoperative assessment of perforators by CT angiography is necessary for a successful outcome [29].

The flap is harvested by dissecting the perforator until the vascular pedicle of the rectus femoris muscle is reached. When dissection of the perforator is finished, the flap is elevated and carefully transferred through a previously created muscle tunnel to reach the recipient site. Care must be taken to avoid torsion or kinking of the pedicle, as well as injury of nerves inside the tunnel. If the pedicle is too short, or if there is tension in the pedicle, conversion to a free flap is indicated. Two nerves are always taken with the flap and anastomosed with ilioinguinal and dorsal clitoral nerves. Split-thickness skin graft is used to cover the donor site.

Several methods for urethral reconstruction in ALT flap phalloplasty are described. The antero-lateral thigh flap is seldom thin enough to be reconstructed using the tube-in-a-tube principle, especially in female-to-male persons, who have gynoid habitus, thicker thighs, and consequently excess flap thickness. For this reason, ALT phalloplasty in this population requires other urethroplasty techniques, and various free flaps and grafts are reported as a solution in these cases – radial free forearm flap, superficial circumflex iliac artery perforator (SCIAP) flap, flap prelamination with skin graft, peritoneal flap. However, most of these procedures have uncertain outcomes [30].

Free Flap Urethroplasty

Free flap urethral reconstruction was originally described in oncological cases, but also as salvage option after partial necrosis of the neourethral part of a tube-in-tube phalloplasty, or in patients who are not eligible for a tube-in-a-tube RFFF or ALT phalloplasty, but who do wish to void in the standing position. The use of the RFFF, gracilis flap, ulnar flap and pedicled superficial circumflex iliac artery perforator flap (SCIPF) are described for urethral reconstruction [27, 31, 32]. The RFFF is a superior flap, with thin skin and a long vascular pedicle, which makes it suitable for urethral reconstruction and microsurgical vascular anastomosis in the groin. It provides the most effective single-stage urethral reconstruction, without the distinctive scar in the forearm. The disadvantage is that it requires a complex, microvascular surgery, performed together with a pedicled perforator flap. A rectangular RFFF of approximately 3 × 16 cm is designed and harvested from the non-dominant forearm. Donor site is closed primarily or covered with a split-thickness skin graft. The vascular pedicle is carefully dissected from the distal to the proximal end, to its origin at the brachial artery. The flap is tubularized in two layers around an 18 Fr Foley catheter with the skin facing the catheter. Labia minora flaps are created on both sides, and conjoined over a catheter to lengthen the native urethra. After elevation of the RFFF and pedicle dissection, the flap is trans-

ferred to the genital region. First, the urethral anastomosis with previously formed bulbar part is performed in a two-layer fashion. The vascular pedicle is tunneled to the groin, the radial artery is anastomosed to the common femoral artery and the cephalic vein to the great saphenous vein. In this way, complete urethral lengthening is performed as a single-stage procedure. However, long-term urethral complications are reported in more than 50% of cases, including urethral stricture, fistula and hairy urethra. Also, microsurgical anastomosis carries a risk of vascular accidents and flap loss [27, 32].

67.2.2.3 Musculocutaneous Latissimus Dorsi (MLD) Free Flap Phalloplasty

The musculocutaneous latissimus dorsi flap has useful anatomical attributes for phallic reconstruction (good size, volume and length of the neurovascular pedicle), and therefore represents our method of choice for neophalloplasty in male transsexuals. In gender affirmation surgery, this technique includes creation of a neophallus using a latissimus dorsi musculocutaneous free flap, its fixation in the pubic region, microvascular anastomosis at the recipient site and reconstruction of the scrotum [33].

Clitoral lengthening and repositioning are performed by complete detachment of dorsal clitoral ligaments from the pubic bone, to mobilize the clitoris and enable its fixation at the base of the neophallus. All vascularized labial and clitoral flaps are used for maximal urethral lengthening. The perineum is reconstructed to achieve a male appearance, the scrotum is created using labia majora. A 15 × 13 cm average-sized flap is designed on the non-dominant side, consisting of two parts – a rectangular part for the neophallic shaft and a circular part for the neoglans. Flap harvesting starts with an incision of the anterior skin margin down to the deep fascia. The plane is developed between the latissimus and anterior serratus muscle, using sharp and blunt dissection, and the flap is lifted to expose the neurovascular pedicle. The pedicle, surrounded by fatty tissue, is identified and dissected up to the axillary vessels. The thoracodorsal nerve is identified and

isolated proximally for 3–4 cm, preserving its vascularization. The flap is completely elevated, but the neurovascular bundle is left in place and is not transected until the recipient vessels and nerve have been prepared for anastomosis. The flap is tubularized while still on the pedicle, creating the neophallus. The distal end is closed to create the glandial part of the neophallus. Completely created neophallus is then detached from the axillar region, after clamping and dividing the subscapular artery, vein and thoracodorsal nerve at their origin, in order to achieve maximal pedicle length. The donor site is approximated and closed directly. In case of significant tension, the defect is covered with split-thickness skin graft. All neurovascular structures at the recipient site are identified, the neophallus is transferred to the pelvic area and a microsurgical vascular anastomosis is performed. The neophallic base is positioned and fixed at the recipient site [34].

Urethral lengthening in MLD free flap phalloplasty can be performed in the same stage, using the same principles of urethroplasty like in metoidioplasty, or as a staged procedure. In one-stage urethroplasty, all available vascularized genital flaps (labia minora, clitoral skin) are used to lengthen the urethra to the proximal third of the neophallus. In some cases, it is enough to enable voiding in standing position. For additional lengthening, staged urethroplasty with buccal mucosa graft is performed.

One-Stage Urethroplasty

The native female urethra needs to be lengthened at least 13–15 cm to enable voiding in standing position. Using the same principle of urethral reconstruction as in metoidioplasty, it is possible to create a neourethra long enough to make voiding while standing feasible after one-stage surgery [2, 34].

Urethral reconstruction starts with the formation of the bulbar urethra. A vaginal flap is harvested from anterior vaginal wall, with its base close to the native meatus, and anastomosed with the proximal urethral plate to form the bulbar part of the urethra. All suture lines must be covered with another layer to prevent urethral fistula formation at this point, where the urinary

stream pressure is the highest. All available vascularized genital tissue, both labia minora, and hairless clitoral skin are used for further lengthening (Fig. 67.3a). The inner surface of both labia minora is dissected to create flaps of appropriate dimensions, without detachment from the outer labial surface (Fig. 67.3b). This is how excellent vascularization of the flap is secured. Flaps are then joined with a running suture to create a tube. Available clitoral skin is used for further lengthening of the urethra over a 12–14 Fr catheter (Fig. 67.3c, d). Both types of flaps, labial and clitoral, have well-developed supportive tissue that prevents fistula formation. In this way, the opening of the neourethra is positioned in the proximal third of the neophallus, leaving the possibility to void while standing in some cases and minimizing the requests for longer neophallic urethroplasty (Fig. 67.3e). Urethral catheter is left indwelling for 2 weeks, and

suprapubic tube for 3 weeks after surgery. Flushing of the neourethra with saline and daily dilations with an 8Fr catheter are recommended until beginning of voiding.

Mean length of the neourethra created in this one-stage procedure is reported to be 14 cm [2]. In this series, urethral opening reached the proximal third of the neophallus in 80% of cases, and further lengthening was performed in 65% of patients, using buccal mucosa grafts.

Staged Urethral Lengthening

Staged urethroplasty is another technique for the reconstruction of the neophallus urethra, based on the two-staged principle introduced by Johanson [9]. The first stage includes creation of the new “urethral plate” using a buccal mucosa graft. Buccal mucosa has established itself as the gold standard in urethral reconstruction. In addition to favorable donor site morbidity, the buccal

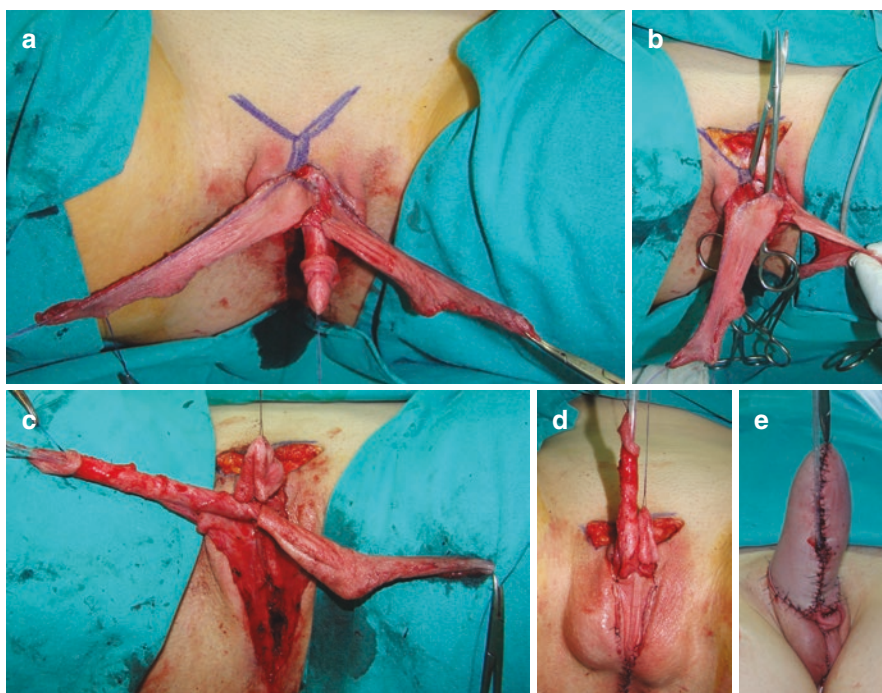


Fig. 67.3 One-stage urethroplasty in total MLD free flap phalloplasty. (a) Both labia minora and hairless clitoral skin are harvested to create very long fasciocutaneous flaps for urethral lengthening; (b) A button-hole maneuver is used to transfer the flaps on the ventral side; (c) Proximal urethra is created with the vaginal flap and the

urethral plate. The well-vascularized genital flap is tubularized for further urethral lengthening; (d) A very long neourethra is created. Clitoral glans is placed at the base of the recipient area; (e) The neophallus is positioned and fixed at the recipient site. Urethral opening is positioned in the proximal third of the neophallus

graft contains the following features, making it an ideal candidate for graft tissue: easy to access and harvest, hairless, durable as full-thickness graft, viable in a wet environment, and has a thin lamina propria that facilitates neovascularization [35]. In female-to-male phalloplasty, surrounding vascular support for graft neovascularization is insufficient compared to a male penis, because cavernosal bodies and spongiosal tissue are missing. This may increase the risk of graft failure. For this reason, suturing of the graft to the underlying neophallic tissue, both along the edges of the graft and the middle, potentially improves graft imbibition and prevents graft contraction. The principles of harvesting and transfer are the same as previously described [15, 22]. The buccal mucosa graft is harvested from the inner cheek. The submucosal region is initially infiltrated with a solution of 0.25% bupivacaine in 1:200000 epinephrine to minimize bleeding at the donor site. Special care should be taken to preserve the integrity of the buccinator muscle, the underlying branches of the facial nerves, as well as the external orifice of the parotid gland. The donor site is checked for bleeding and closed with a running suture, or left open for secondary healing in case a large mucosal defect is created. The size of the graft depends on the size of the planned neophallic urethra. If more graft material is needed, it can be harvested from the other cheek. Labial and lingual graft harvesting results in higher graft site morbidity, and should be avoided [36].

First Stage: Urethral Plate Creation

Urethral reconstruction is performed 6 months after phalloplasty. Neophallus is opened in the midline to create a space for the “urethral plate”. The buccal mucosa grafts are placed and quilted on the ventral side of the neophallus, starting from the advanced urethral meatus to the glans, therefore creating a neophallic urethral plate. Edges of the plate are sutured to the neophallic skin in an elevated fashion, to create a groove in the midline (Fig. 67.4). Wetting of



Fig. 67.4 First stage urethroplasty. Buccal mucosa grafts are placed and quilted on the ventral side of the neophallus, from the advanced urethral meatus to the glans, to create a new urethral plate. A groove is formed in the midline

the grafts with saline in the first 72 hours post-operatively, followed by local application of hydrating cream, is essential for graft survival. The patient has to be instructed for this local treatment until the next stage.

Second Stage: Tubularization of Urethral Plate

Second stage should be performed when the “urethral plate” has matured enough to be supple and thus easily mobilized for tubularization, usually four to 6 months later (Fig. 67.5a). The classic mistake is to perform second stage too early. If it is necessary, additional buccal mucosa grafts can be used at the second stage for urethral plate augmentation and easier tubularization. Edges of the plate are mobilized and tubularized in a tension-free manner over a 12–14 Fr catheter to complete neophallic urethroplasty (Fig. 67.5b, c). It is important to incise the underlying tissue that will support the neourethra and avoid tension and ischemia at the neourethral suture line. It is recommended to create a second layer from surrounding tissue to cover and support the neourethra, in absence of spongiosal tissue (Fig. 67.5d). Subsequently, previous urethral opening is mobilized and anastomosed to the neophallic urethra to complete urethral lengthening. A suprapubic catheter is used for urine drainage for 3 weeks, while urethral catheter is removed 2 weeks after surgery.

In cases where the newly created neophallic urethra seems too long, and likely to heal with complications, an anastomosis with previous urethral meatus is skipped and constitution of a complete channel is left for the third stage. In this case, a catheter is left indwelling in the neophallic urethra for the next 2 weeks, and the patient continues to void from the previously created opening, like before surgery. After the catheter is removed, the patient is advised to perform dilations of the new neophallic urethra, twice per day with 8–10 Fr catheter to keep the channel patent until complete closure. The next stage is performed after three to 6 months and includes simple mobilization and joining of openings in the proximal part of the neophallus. A suprapubic tube leaves the anastomosis site urine-free for complete and safe healing.

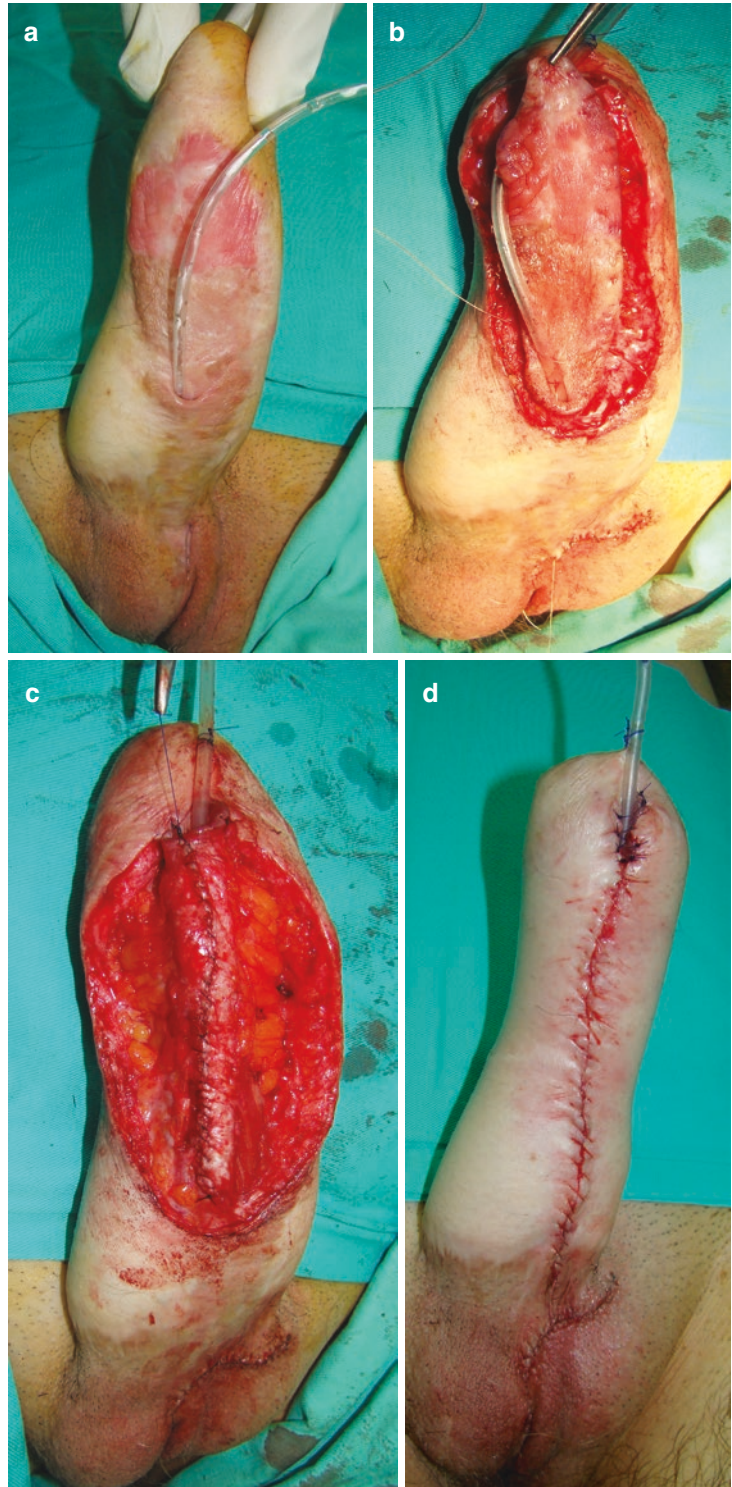
With the Johanson principle, buccal mucosa graft presents the optimal option for staged urethroplasty. It is suitable in all types of female-to-male phalloplasty, with an acceptable rate of complications.

67.3 Summary

Urethral reconstruction in female-to-male gender affirming surgery is a complex and highly specialized procedure. The main goal for the patient is the ability to void in standing position, without urethral complications. In order to achieve this, it is necessary to create a very long and functional neourethra from the native female opening to the top of the neophallus. In total phalloplasty, one-stage ‘tube-in-a-tube’ urethroplasty or staged procedure with combined buccal mucosa graft and genital flaps are most commonly used, and the incidence of complications has been reduced with refinements of these procedures. The techniques of metoidioplasty have evolved significantly, mostly due to improvements in urethral reconstruction. Advanced urethroplasty using combined buccal mucosa graft and genital flaps, represents the main advantage of one stage metoidioplasty at present, with good results.

Materials and approaches for urethral reconstruction in female-to-male gender affirmation surgery are constantly evolving. Tissue engineering urethroplasty may be a solution in the future, but is still experimental. Although numerous strategies are available, there is still no single optimal solution suitable for all cases. The selection of urethroplasty technique should be carefully tailored for each individual patient, to achieve a successful outcome: voiding in standing position, prevention of complications, and patients’ satisfaction. The transgender surgeon must be familiar with a variety of techniques to ensure choosing the best procedure in every single case. Still, it is our duty to keep searching for new and better solutions.

Fig. 67.5 Second stage urethroplasty: (a) Appearance 6 months after the first stage. New urethral plate is ready for tubularization; (b) Edges of the plate are mobilized from the neophallic skin; (c) Plate is tubularized in a tension-free manner over a catheter; (d) Appearance after surgery. Neophallus is closed to cover neourethra without tension



Key Summary Points

- There are two surgical options for female-to-male gender affirming phalloplasty: metoidioplasty and total phalloplasty.
- Voiding in standing position is one of the main goals in female-to-male gender affirmation surgery.
- Urethral lengthening is performed as a one-stage or multi-staged procedure, mainly depending on the type of phalloplasty.
- Urethral reconstruction includes creation of the bulbar, neophallic and glandial neourethra.
- Meticulous reconstruction of the bulbar urethra in a funnel-shaped fashion, with vaginal or periurethral flaps, is necessary for a successful outcome.
- One-stage, advanced urethroplasty by combined buccal mucosa graft and labia minora flap is the method of choice in metoidioplasty, resulting in minimal complication rate.
- “Tube-in-a-tube” urethroplasty is the method of choice in radial forearm free flap phalloplasty.
- Free flaps (radial forearm free flap, gracilis flap, ulnar flap, pedicled superficial circumflex iliac artery perforator flap) should be avoided due to procedure complexity and the necessity for microvascular surgery with a risk of flap loss.
- A single-stage urethral lengthening to the proximal third of the neophallus can be performed simultaneously with pedicled or free flap phalloplasty, by using all available genital flaps (both labia minora, clitoral skin).
- Staged urethral reconstruction with buccal mucosa graft and neophallus skin is a safe and viable procedure.

Proper perioperative care is necessary for a successful outcome of urethroplasty in female-to-male gender affirming surgery.

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Penile Reconstruction after Trauma and in Gender Dysphoria

68

Marco Falcone and Giulio Garaffa

68.1 Historical Considerations

Due to the unique anatomy of the male genitalia and to the lack of tissue that may adequately replace the smooth muscle of the cavernosal bodies and the spongiosum, total phallic reconstruction (TPR) still represents a real challenge for the reconstructive surgeon.

The main goals of a TPR are the creation of a cosmetically acceptable phallus with both tactile and erogenous sensation. Ideally, the phallus should have an incorporated neourethra, to allow the patient to void and ejaculate from the tip of the neoglans and adequate bulk to allow the insertion of an internal stiffener to guarantee the rigidity necessary to successfully engage in penetrative sexual intercourse.

The first historical attempts aiming to reconstruct a phallus were based on abdominal flaps. The first TPR was described in 1936 by Nikolaj Bogoras, a Russian surgeon, who used a random pedicled oblique abdominal flap. He achieved phallic rigidity inserting a cartilage rib inside the flap [1].

Subsequently, Matz and Gillies, imported the idea to incorporate a neo-urethra in the phallus in a “tube within a tube” fashion in the attempt to restore both urinary and ejaculatory functions [2]. However, these procedures had several limitations. Indeed, they required multiple procedures, they resulted in extensive scarring and disfigurement of the donor area, as the phallus was progressively transferred in stages to the recipient site, and last but not the least they lead to the creation of a non-sensitive phallus. Therefore, to date, these techniques should be considered only as salvage procedures after a failed phalloplasty.

Infraumbilical and groin skin flaps have the advantage of requiring a limited number of surgical stages and of causing an acceptable donor site morbidity but produce a non-sensitive wedge-shaped phallus [3–5].

Gracilis miocutaneous flaps have been abandoned due to poor cosmetic results, as the muscle tends to scar down and contract [6].

In the 80’s, the advent of microsurgical techniques and their application in reconstructive surgery revolutioned the concept of TPR, as they allowed to transfer tissue as free flaps in a single stage even when donor and recipient site were distantly located. In 1982, Song and Chang were the first Authors to describe the use of radial artery based free flap (RAFF) for phallic reconstruction in a series of patients that had suffered traumatic amputation of the penis [7]. The

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reconstructive procedure involved the creation of a phallus according to the 'tube within a tube' concept using a fascio-cutaneous flap usually harvested from the non-dominant forearm. The neo-urethra was usually fashioned from the less-hairy medial aspect of the flap. The vascular supply of the flap was based on the radial artery, on the "venae comitantes" of the radial artery and on 1 to 2 main veins. Tactile and herogenous sensations were both guaranteed by the anastomosis between the antebrachial nerves and the dorsal nerve of the penis and the ileo-inguinal nerve.

After the initial cases described by Song and Chang, many other Authors have introduced personal modifications in flap design in order to improve the cosmesis of the neophallus and to minimize the incidence of complications and the donor site morbidity [8–10].

Also, an ulnar artery-based variant of this flap has been described, aiming to reduce the amount of hair bearing skin incorporated in the neourethra, as the medial aspect of the forearm tends to be less hairy than its lateral counterpart [11, 12].

Up to date, the main types of phalloplasty available are:

1. The radial artery phalloplasty (RAP), which is performed as a free flap
 2. The infraumbilical phalloplasty also known as pubic phalloplasty (PP), which is performed as pedicled
 3. The anterolateral thigh flap (ALT), which can be performed either as a pedicled or as a free flap
 4. The latissimus dorsi flap (LD), which is performed as a free flap
1. *The radial artery forearm free flap phalloplasty (RAP)*

Although it does not represent the ideal technique, the RAP is so far considered the gold standard technique as it guarantees superior cosmetic and functional results compared to the other techniques available. Indeed, it allows the formation of a cosmetically acceptable sensate neophallus with an incorporated neourethra, which reaches the tip of the neoglans. Various Authors have

demonstrated that this technique represents a valuable option in patients following penile amputation for carcinoma or trauma, in patients with penile inadequacy and in female to male sex reassignment surgery [8, 13–15].

Despite the main limitation of this approach which is represented by the visible scar at the level of the donor site on the non-dominant forearm, representing stigma in these patients, functional limitations and sensory changes are rare, as confirmed by multiple large series published in the literature [9, 16, 17].

Surgery is performed only after the competency of the superficial and deep palmar arteries has been tested with an Allen test. Duplex sonography is reserved to these patients who had a negative or inconclusive test. Laser or electrolysis-based hair removal from the forearm can represent a valuable tool to improve the cosmesis and minimize hair growth in the neourethra, which may lead to stone formation, recurrent urinary tract infections and voiding dysfunction.

Typically, the TPR with a modified radial artery based free flap is carried out in the following three stages, which are carried out at an average of 6 months' intervals to guarantee a complete scar maturation:

1. Creation of the neophallus with competent neourethra and transfer to the recipient site as a free flap with microsurgical technique.
2. Sculpture of the glans and creation of a pseudo-corona according to the Norfolk technique with the use of a full thickness skin graft to fashion the ridge and the groove of the neoglans. This stage is meant to render the cosmetic aspect of the phallus more realistic.
3. Insertion of an artificial stiffener, ideally a penile prosthesis into the neophallus to guarantee the rigidity necessary to engage in penetrative sexual intercourse in patients keen to be sexually active. Inflatable penile prosthesis are less associated with pressure sores than their semirigid counterpart and, therefore, they represent the preferred option.

Although the RAP is far from being an ideal technique, penile reconstruction with this

approach has proven superior to all other techniques since it:

1. Guarantees a superior cosmetic result by forming a cylindrical phallus rather than the wedge shaped one that is obtained using infra umbilical and groin flaps.
2. Allows the creation of a neourethra that reaches the tip of the phallus, which is significantly less prone to complications than skin graft urethroplasty. Urethral complications with other types of phalloplasties are extremely common and require multiple revisions. This is the main advantage of this technique when compared to the latissimus dorsi flap, where the only way to fashion a neo-urethra is with a prelaminated buccal mucosa graft applied directly on the muscular portion of the flap and is tubularized over a stent 4–6 months afterwards
3. Allows the creation of a sensate phallus whereas in other phalloplasties the sensation is minimal (anterolateral thigh flap and latissimus dorsi flap) or absent (Gillies flap and distal 2/3 of infraumbilical flap).

Donor site morbidity can be dramatically reduced by adequate preparation of the donor site for grafting. This involves adequate hemostasis and the advancement of the edges of the intact forearm skin to reduce the area that requires grafting and to minimize the step between normal skin and the grafted muscle. With regards to the type of skin graft, thick grafts have proven to be superior to thin grafts as they heal with less scarring and discoloration [17, 18]. Alternatively, excellent results can be achieved with the interposition of a porous matrix of cross-linked bovine tendon collagen between the recipient bed and a split thickness skin graft in order to recreate the appearance of a subcutaneous tissue.

In the past, bone and cartilage grafts have been widely used and incorporated in the neophallus in the attempt to guarantee the rigidity necessary to engage in penetrative sexual intercourse. Currently, the best results in terms of rigidity, capacity to conceal and reliability are achieved with the insertion of an inflatable penile prosthesis [19–21].

2. *Infraumbilical (pubic) phalloplasty (PP)*

This technique, most commonly used for TPR in female to male transsexuals [22], can be modified for use in traumatic amputation patients, although no published data is available for this group. The advantages of this technique are that it is easily reproducible, does not require microsurgical skills and the operating time is relatively short. Additionally, another advantage of this technique is that the donor site scarring is limited to the abdomen, which is easily concealable when compared to the forearm or the thigh. The main drawbacks of this technique are the creation of a wedge shaped, hairy phallus, which lacks a neourethra and is insensate for the distal two thirds of its length.

The phallus is fashioned from a cutaneous flap that is raised from the inferior aspect of the abdominal wall (Fig. 68.1). Usually the dimensions of the flap are 12 cm in width and 12–14 cm in length, which is measured from the base of the

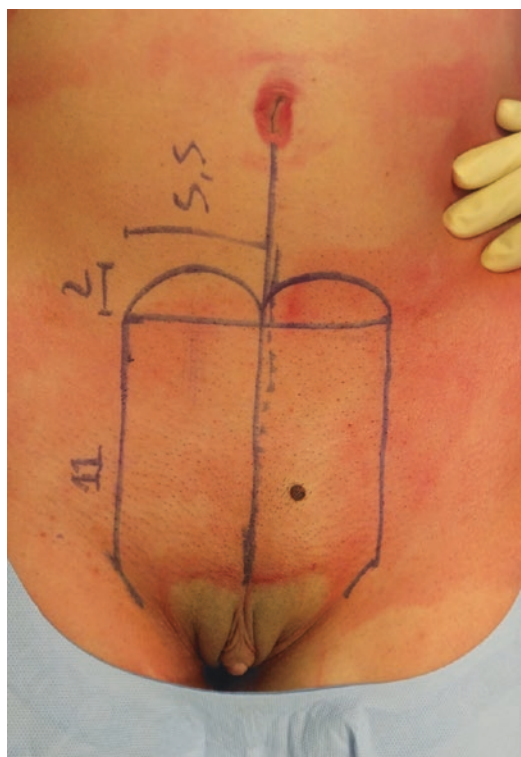


Fig. 68.1 Design of a suprapubic pedicled phalloplasty

pubis. Where possible, the superficial external pudendal vessels are incorporated into the base of the pedicle. The anterior abdominal wall skin is then dissected off the rectus fascia and mobilized caudally to enable a primary closure of the donor site defect avoiding the need for skin grafting.

The subsequent steps of glans sculpture and prosthetics are similar to the ones previously described for the RAFF. Since urethral complications associated with a staged skin graft urethroplasty are high in terms of contracture and fistula formation, patients can be offered a delayed incorporation of a radial artery based neourethra into the neophallus (radial artery urethroplasty). The procedure, involves the microsurgical transfer of a radial artery based 4 cm wide flap harvested from the inner aspect of the non-dominant forearm. Once tubularized around a stent, the flap is fitted in a previously fashioned pubic phalloplasty. In expert hands, this procedure is associated with low complication rates, in terms of stricture and fistula formations and it is not prone to sacculation [23].

3. Antero-lateral thigh flap phalloplasty (ALT)

The ALT flap is a reasonable option in patients requiring a TPR [24, 25]. This is a fascio-cutaneous flap based on the perforator vessels through the vastus lateralis and rectus femoris from the descending branch of the anterior circumflex femoral artery. The ALT flap is very reliable from a vascular point of view and is commonly used in reconstructive surgery. For total phallic reconstruction purposes, a 16 × 16 cm (16 × 20 cm if incorporating a neo-urethra) flap needs to be raised. The dissection is more difficult compared to the radial forearm flap because the perforator vessels need to be released from the surrounding fiber of the rectus muscle in around 85% of cases. Frequently there is a pedicle long enough to reach the pubic area after the tunneling of the flap under the rectus femoris tendon, which then obviates the need of any microsurgical vascular anastomosis. However, the main drawbacks of the ALT flap are the presence of a thick subcutaneous layer and the presence of a conspicuous amount of hair. These characteristics render simultaneous neo-urethral

construction using the “tube within tube” technique difficult. Often the phalloplasty is made from the ALT flap and the neo-urethra is then formed from a 4 cm wide radial forearm flap, with a principle similar to the one previously described for infraumbilical phalloplasty and radial artery urethroplasty [23]. There is only one cutaneous nerve within the ALT flap so the potential sensation is not as good as in case of radial artery phalloplasty. Careful patient selection is therefore particularly important to achieve good cosmetic results. Because of the large size of the donor site defect, a split skin graft is used to cover the donor site. Although donor site scarring tends to be poor, the area can be easily hidden even if the patient is wearing short trousers.

4. Latissimus dorsi flap (LD)

The latissimus dorsi flap represents another valid alternative for total penile reconstruction [26]. It is a myocutaneous flap based on the thoracodorsal artery, which is a descending branch of the subscapular artery.

Usually a large skin flap, up to 15 cm wide and 20 cm long can be raised on a 3–4 cm strip of latissimus dorsi muscle, as there are many reliable perforators around the anterior intramuscular branch. This technique allows the creation of a sensate phallus, as the thoracodorsal nerve, which runs alongside the thoracodorsal artery and vein, guarantees the innervation of the flap.

The main advantage of LD flap phalloplasty is the limited donor site morbidity as the defect can be primarily repaired without the use of a skin graft and with minimal scarring. However, the TPR requires forcedly multiple stages. The first is phallus formation with microsurgical tissue transfer techniques to the recipient area. At this stage, the neophallus does not contain a neo-urethra as the flap is too thick to allow the creation of a neo-urethra with a “tube within a tube” concept. A “prelaminated” urethra can therefore be fashioned in two stages using buccal mucosa grafts, which are applied on the muscular strip of the flap. Using this technique urethral strictures and fistulae are common. Penile prosthesis implantation is performed using the same technique described for

the RAP once sensation has resumed and flap/urethral complications dealt with.

68.2 Penile Amputation Following Trauma

Although genital injuries in civilian centers are not frequent, the scenario is completely different in the battlefield, where the use of protective torso armour, to protect the abdomen, has led to the survival of patients with extremely severe injuries to the genitalia and lower limbs caused by fragmentation weapons. On the contrary, the most common cause of genital trauma in civilians are self-amputation after an acute psychotic episode, road traffic accidents, gunshot or blast wound, Fournier's gangrene and sexual assault. In case of avulsion injury, the penis can be adequately preserved in sterile ice sluice for up to 24 hours and a microsurgical reimplantation can be successfully attempted within this time frame. If the penis is not adequate for primary reimplantation or it cannot be found, then delayed penile reconstruction needs to be considered [13].

68.3 Penile Trauma Classification

The Rashid and Sarwar [27] classification is commonly used to describe penile traumatic amputations:

- Type I – The most proximal part of the corporal stump and of the urethra are present and palpable; the urinary meatus reaches the tips of the corporal stump; the scrotum and the testicles are preserved.
- Type II – The pendulous corpora cavernosa are absent. The crura are preserved and the urethra is transected at the level of the pubic symphysis; the scrotal skin is partially lost.
- Type III – The corpora are totally absent; the patient voids through a perineal urethrostomy.
- Type IV – The corpora are totally absent and the urinary meatus is not visible in the perineal region. The patient voids through a urinary diversion (often a suprapubic catheter).

68.4 Surgical Strategies to Optimize Penile Length

In selected cases of Type I trauma, a lengthening procedure aiming to optimize the residual stump may be considered. In case of inadequate proximal penile stump a TPR is advised [28].

The following procedures can be performed in isolation or be combined in order to optimize the length of the residual penile stump:

1. *Prepubic V-Y plasty*
2. *Suspensory ligament division*
3. *Scrotoplasty with reconstruction of penoscrotal angle*
4. *Penile shaft release followed by repair with skin grafts or local rotational flaps*
5. *Apronectomy or suprapubic fat pad excision*

These procedures, when . Considering that morbidity associated with these techniques is quite low, it is often useful to offer them first and consider a TPR only at a later stage.

68.5 Total Phallic Reconstruction after Penile Trauma: RAP Step-by-Step Technique

The non-dominant forearm is selected as the donor site in all patients. When TPR with the RAP is contemplated, the competence of the superficial and deep palmar arteries of the donor forearm are assessed with the Allen test and with a Doppler ultrasound study when the Allen test result was equivocal. TPR consists of a three-stage operation. *Stage 1* consists in the creation of the phallus with an incorporated neourethra and its microsurgical transfer to the recipient site. *Stage 2* consists in a creation of a pseudo-glans; the native urethra and the phallic one are joined-up together at this stage in patients with type III avulsion. *Stage 3* consists in the insertion of a penile prosthesis into the bulk of the phallus to obtain rigidity sufficient for penetrative sexual intercourse. The stages are usually performed at 4–6 months intervals to allow for complete healing to occur after each operation. Generally, com-

plications arising at each stage, are usually addressed at the subsequent stage to minimize the total operations needed.

68.5.1 Stage 1

Although the size/shape may vary according to the dimension of the forearm, to the type of amputation and to patients' requests, the flap is generally composed by a 17×4 cm medial strip that forms the neourethra and a 13×14 cm lateral paddle that will be rolled around the neourethra to form the phallus according to the "tube within a tube" concept. The two aspects of the flap are separated by a 1-cm-wide de-epithelialized strip of dermis (Fig. 68.2). The flap is based on the radial artery, which is carefully dissected off proximally from its origin with the brachial artery. The superficial venous drainage is normally based on two to three large flap veins and associated to the deep drainage based on the venae comitantes of the radial artery. Sensation is provided by the medial and lateral cutaneous nerves of the forearm and the dorsal penile nerves when available. The flap is raised under tourniquet compression, which ideally should be limited to 2 hours to avoid any prolonged ischemic damage. The medial strip is tubularized over a 16-Fr stent and spatulated on

its proximal side to form the neourethra (Fig. 68.3). Subsequently, the lateral paddle is wrapped around the urethra in a "tube within a tube" fashion to form the phallus (Fig. 68.4). Only relatively hairless skin should be used to fashion the neourethra because hair growth leads to the formation of stones, causing recurrent urinary tract infections and voiding dysfunction. Therefore, patients with significant hair growth on the medial aspect of the forearm are advised to undergo laser hair removal before surgery.

The recipient site is prepared, with preservation, when possible, of stump of corpora cavernosa and urethra. When preserved, the nerves and vein of the neurovascular bundle are isolated and prepared for microsurgical anastomosis.

The proximal stump of the corpora cavernosa is cut flush with the pubic skin to guarantee a better phallic shape. When possible, it is advisable to leave two long rear tip extenders of a penile implant or a soft malleable rod in each crus to aid their identification when inserting the penile prosthesis during stage 3. The tunica albuginea of the corpora is then closed in a water-tight fashion above the implant to prevent hematoma formation. In type I and II injuries, the proximal end of the healthy urethra is spatulated and primarily anastomosed in end-to-end fashion with

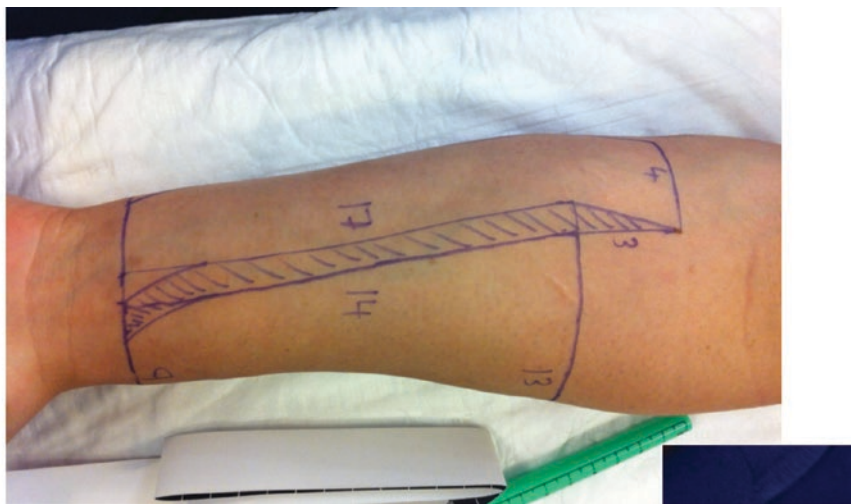


Fig. 68.2 Design of a radial artery forearm free flap phalloplasty from left forearm

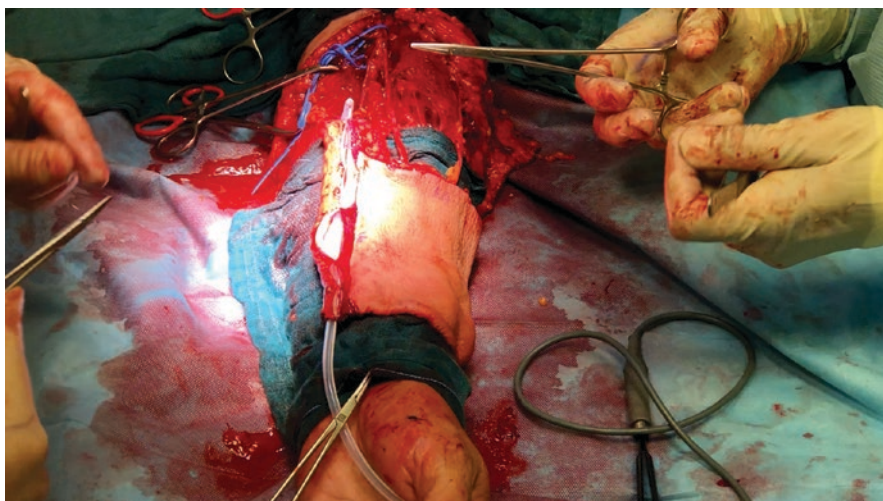


Fig. 68.3 Tabularization of the urethral strip around a 16 F urethral stent



Fig. 68.4 Final aspect of the neo-phallus after the lateral paddle is wrapped around the urethra in a “tube within a tube” fashion

the phallic neourethra; in type III injuries, the proximal part of the neourethra is anastomosed to an inverted U-shaped flap of scrotal skin to allow for a subsequent anastomosis to the native urethra in stage 2. Once the phallus is transferred to the recipient site, microsurgical vascular and nervous anastomoses are performed. The main flap veins are connected to the long branches of the saphenous, to the deep dorsal vein of the penis, or to the venae comitantes of the inferior epigastric artery. If the neurovascu-

lar bundle is preserved, the flap nerves are connected to the dorsal nerve of the penis in order to guarantee both tactile and erogenous sensation. Alternatively, anastomosis is performed with the ilio-inguinal and ilio-hypogastric nerves (Fig. 68.5).

The donor arm defect is covered with a thick split-thickness skin graft (STSG) usually harvested from the lower buttocks, abdomen, or axilla, according to the patient's body habitus (Fig. 68.6).

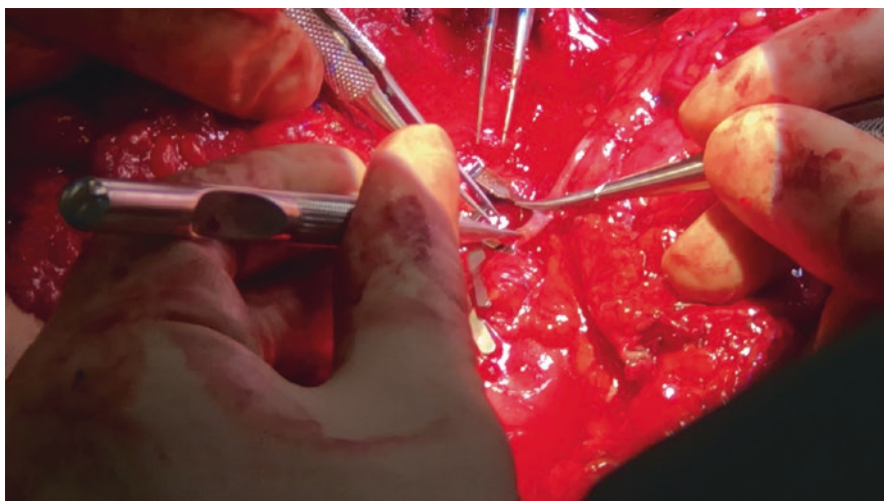


Fig. 68.5 End to end vascular micro-anastomosis of the inferior epigastric artery to the radial artery



Fig. 68.6 Final aspect of the forearm defect after full-thickness skin graft is completed

68.5.2 Stage 2

A pseudo-glans is sculptured according to Norfolk technique to create a cosmetically acceptable phallus. The Norfolk technique allows

the creation of a glans ridge and of a coronal groove and is performed at least 3 months after the formation of the phallus in order not to compromise his distal blood supply.

68.5.3 Stage 3

For the final stage of the reconstructive process, an inflatable penile prosthesis is inserted into the phallus to guarantee the rigidity necessary for penetrative sexual intercourse. Typically, a classical penoscrotal incision is performed to allow the identification of proximal corporal stumps. Usually identification is not difficult, thanks to the presence of the malleable rods or rear tip extenders. After a channel is obtained in the bulk of the phallus with sharp dissection, a progressive blunt dilation is performed using Hegar dilators up to 18 Fr. The length of the phallus is measured with a Furlow dilator and the size of the implant decided accordingly. To decrease the risk of distal erosion, a windsock is fashioned in vascular prosthetic material to house the tip of the implant (Fig. 68.7). The reservoir is placed in the retropubic space in the traditional fashion. A suction drain in the scrotum and a compressive dressing are left in place for 24 hours to minimize hematoma formation. The device is left semi-inflated for 7 days for hemostatic purposes and to provide

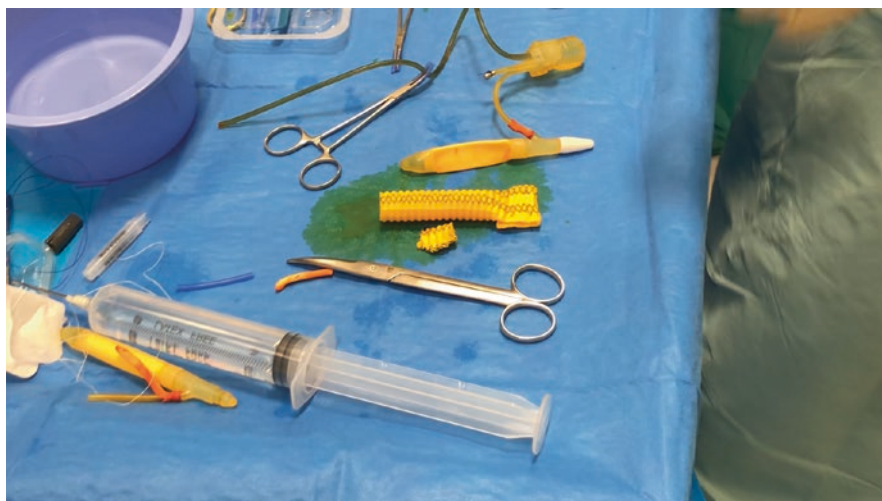


Fig. 68.7 Configuration of a single-cylinder inflatable penile prosthesis with Dacron sock and cap

enough time for the formation of a pseudocapsule around the cylinders. Usually patients are trained how to cycle the device 4 weeks postoperatively and are encouraged to resume sexual activity after 6 weeks.

68.6 Total Phallic Reconstruction after Female to Male Gender Dysphoria: RAFF Step-by-Step Technique

The main goal in female-to-male sex reassignment surgery is the creation of a cosmetically acceptable sensate phallus with an incorporated neourethra, to allow patients to void while standing in a male urinal, and with enough bulk to allow the insertion of a penile prosthesis for sexual penetration.

According to our experience, the TPR using a modified Chang and Hwang RAP flap leads to excellent results and it represents therefore our preferred approach.

The process of TPR involves the following stages: (1) creation of the phallus with a competent neourethra and microvascular transfer to the recipient site, (2) anastomosis of the native urethra to the phallic urethra with the use of local labial flaps, sculpture of the glans according to the Norfolk technique (3) insertion of a penile

implant into the phallus. Usually, hysterectomy and bilateral salpingo-oophorectomy and vaginectomy are performed at stage 2. Each stage is done at 4 months intervals, with complications of one stage being dealt with during the following stage to reduce the overall number of operations.

68.6.1 Stage 1

Although this stage is similar to what previously described for patients who had experienced penile amputation, in female to male transsexuals the urethral anastomosis with the native urethra is not performed in the first stage and the neourethra is left spatulated on the lateral aspect of the clitoris.

68.6.2 Stage 2

Approximately 4 months after the initial phallic construction, the proximal end of the neo-urethra is anastomosed to the native one with the use of local labial flaps over a 16 French stent, which is left in place for 1 week.

It is paramount to mobilize the flaps with care and closing in multiple layers in order to minimize the risk of stricture and fistula formation

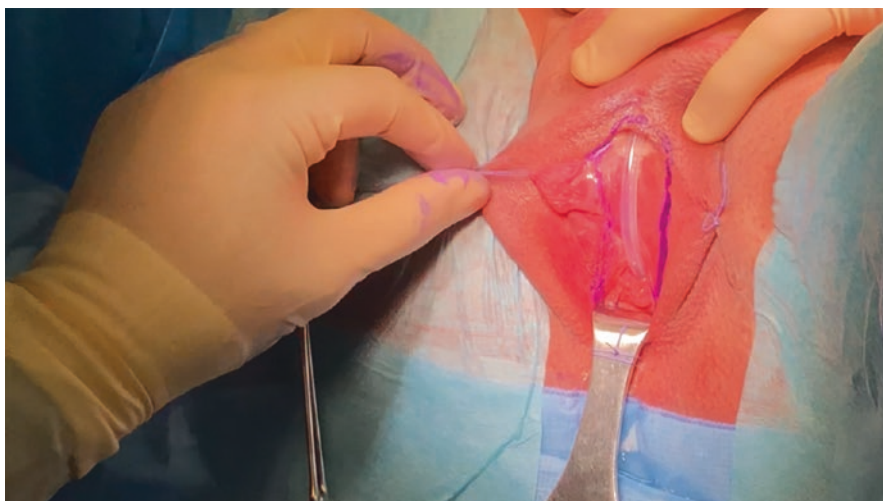


Fig. 68.8 Design of the urethral plate in a join-up urethroplasty



Fig. 68.9 Final appearance of neo-scrotum and perineum after the join-up urethroplasty, vaginectomy and scrotoplasty

(Fig. 68.8). Typically, a suprapubic catheter is left in place for 4 in order to minimize complications.

During this stage, a pseudo-scrotum is formed suturing the labia majora along the midline (Fig. 68.9). At this stage patients are given the choice whether they want to leave the clitoris exposed or not and whether they wish to undergo a vaginectomy.

During this stage, a pseudo-glans is then fashioned using the aforementioned Norfolk technique. The final appearance of the neo-phallus is shown in Fig. 68.10.



Fig. 68.10 Final appearance of a neo-phallus after the glans sculpting

68.6.3 Stage 3

This stage involves the insertion of an inflatable penile prosthesis in the phallus as previously described in the penile trauma section.

68.7 Discussion

After the initial reports by Song et al. and Chang and Hwang [7, 29] of TPR using the RAFF, this technique has been successfully described both in the genetic male and in female-to-male transsexuals [13, 15, 23]. Although several other flaps have been described over the years, the RAP seems to represent the best solution available at present. It guarantees an excellent cosmetic outcome because it allows the formation of a sensate phallus with an incorporated neourethra. The phallus has a nice cylindrical shape rather than the wedge shape typical of infraumbilical and groin flaps. Because no muscle is incorporated into the phallus, the RAP appears less prone to postoperative contracture than musculocutaneous flaps. Another advantage of TPR with the RAP is that it does not produce abdominal disfigurement and requires only three surgical stages.

The main drawback of this technique is donor site morbidity. Although loss of function is virtually absent, the scar represents a stigma in this group of patients, especially considering that it is located in a very visible area [17, 18].

Most of the largest series of RAFFF are based on female-to-male transsexuals [8]. Smaller series have described this technique in patients who underwent penectomy for penile or urethral cancer and in patients with penile inadequacy [14, 15]. Among the various groups of patients requiring TPR, reconstruction after trauma is surely deemed one of the most challenging, and each patient requires a different approach depending on how extensive the genital loss was. There are only a few case reports of TPR after traumatic penile loss. Rashid and Sarwar published a retrospective analysis on using the RAP after traumatic penile loss based on 36 patients [27]. Urethral complications were common but all could be successfully managed surgically.

Although the series of Rashid and Sarwar represents the largest series of TPR with the use of the RAP, they used an autologous cartilage graft as a stiffener to guarantee the rigidity necessary to engage in penetrative sexual intercourse, as

initially described by Bogoras in 1936 [1]. This solution is certainly suboptimal, as previously discussed in this chapter and currently implantation of an inflatable penile prosthesis represents the best solution to guarantee phallic rigidity. We recently reported a series of ten patients who underwent TPR after traumatic penile amputation [13]. The median follow-up was 51 months and 6 patients completed all stages of the procedure. Only three of the four patients with type III penile avulsion and perineal urethrostomy underwent total urethral reconstruction with a join-up urethroplasty. One patient was not interested in voiding in the standing position. The inferior epigastric pedicle was easily isolated and used as the arterial supply of the phallus in nine patients (90%). In the remaining patient, the two epigastric trunks had been destroyed by the previous trauma and therefore the radial artery was anastomosed end to side to the superficial femoral artery with the interposition of a saphenous jump graft.

An inflatable penile prosthesis was implanted in six patients (five received the AMS 700 CX, Boston Scientific, Marlborough, MA, USA; one received the Titan Zero Degree OTR, Coloplast, Minneapolis, MN, USA), with double cylinders used in four patients for extra rigidity.

Revision surgery was required in three patients for acute infection or mechanical failure and all were managed by explantation and delayed implantation in the infected cases. After revision surgery, all patients could cycle the device to obtain full phallic rigidity and four were able to engage in penetrative sexual intercourse. With regards to functional results, all patients were fully satisfied by the cosmetic appearance, size, and tactile sensation of the phallus, as indicated by the maximum score for each domain of the questionnaire. Urinary function also was fully satisfactory, as all patients were able to void while standing. After revision surgery, all patients who underwent stage 3 of the reconstruction were sexually active after the surgery and they could achieve a fully satisfactory orgasm with masturbation or penetrative sexual intercourse.

68.8 Conclusions

Despite the high incidence of postoperative complications and the possible need for multiple operations, TPR with the RAP yields to excellent surgical and functional results both in the genetic male and in female to male transsexuals.

Key Summary Points

- The most frequent conditions that may require a total phallic reconstruction are gender dysphoria, penile trauma, penile cancer and congenital micropenis
- Total phallic reconstruction represents a real surgical challenge for the reconstructive surgeon
- The main goals of a total phallic reconstruction are: to create a cosmetically acceptable phallus with both tactile and erogenous sensation, to allow the patient to void and ejaculate from the tip of the neoglans and to have an adequate bulk to allow the insertion of a penile prosthesis
- The main types of phalloplasty to date are: (a) The radial artery phalloplasty, which is a free flap phalloplasty (b) The infraumbilical phalloplasty also known as pubic phalloplasty (c) The anterolateral thigh flap (d) The latissimus dorsi flap
- Total phallic reconstruction, despite the burden of a high incidence of postoperative complications and the possible need for multiple operations, yields to excellent surgical and functional results

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Urologic Complications of Gender-Affirming Surgery

69

Min Suk Jun and Richard A. Santucci

69.1 Introduction

A recent meta-analysis of multinational data estimates the prevalence of individuals identifying as transgender to be approximately 355 in 100,000, and 9.2 in 100,000 will seek gender affirming surgery or hormonal therapy. [1] Canner et al. report 37,827 encounters with the ICD-9 code of transsexualism or gender identity disorder from 2000 to 2014 from the National Inpatient Sample, a representative pool of inpatient visits across the United States, of which 10.9% involved gender-confirming surgery. The investigators showed that the number of patients seeking genital surgery more than doubled from 698 in 2000 to 2005 to 1584 in 2006 to 2011. Furthermore, the percentage of individuals seeking gender-affirming procedures and who are covered by Medicare and Medicaid increased from 25% to 70% between 2012 to 2013 and 2014, respectively [2].

Survey data shows that the prevalence of attempted suicide amongst unoperated transgender people is alarmingly high at 32% [3]. Gender affirmation therapy has been shown to significantly decrease psychopathology in the gender dysphoria population [4]. While gender affirming

surgery is not life-saving the way trauma surgery can be, it can nonetheless be a life-saver. With the number of gender affirming procedures on the rise, so too will its related complications, and the reconstructive urologist must be prepared to treat them.

69.2 Complications in the Transgender Male

69.2.1 Metoidioplasty Surgery Overview

The choice between metoidioplasty and phalloplasty is both practical and personal. The ultimate goal of transgender surgery is always relief of the underlying gender dysphoria. Phalloplasty may take a two-surgeon team at least 8 hours to complete while metoidioplasty can be accomplished by a single surgeon in 4 hours or less. Patients may realize that their gender dysphoria may be relieved with the smaller surgery and opt for the less morbid metoidioplasty.

Some other reasons why someone would choose metoidioplasty is that it offers absence of a donor site while allowing for upright micturition. The patient must understand, however, that performing penetrative sexual intercourse is unlikely. Perovic and Djordjevic reported a mean neophallus length of 5.7 cm after metoidioplasty, although this length is often not achievable even

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with maximum phallic lengthening. In this study 17/22 patients (77%) were satisfied, while 5/22 (23%) later decided to undergo phalloplasty [5]. This highlights another benefit of metoidioplasty: if the metoidioplasty proves to be functionally or psychologically inadequate, that the patient first underwent metoidioplasty does not forfeit the option for phalloplasty. In fact, there is benefit to this route as it essentially stages phalloplasty, making surgery less difficult for the surgeon and less taxing for the patient. Lastly, metoidioplasty complications tend to be fewer and more minor than those associated with phalloplasty. These include urethrocutaneous fistulae, urethral stricture, and persistent vaginal remnant. Frey et al. report in their review that the overall complication rate after metoidioplasty is 0.43 per patient versus 0.88 after radial forearm flap phalloplasty [6].

Metoidioplasty requires hormonal enlargement of the clitoris with testosterone followed by surgical elongation to produce a phallic structure that is both aesthetically acceptable and adequate for standing micturition. Furthermore, metoidioplasty preserves the capacity for corporal tumescence while maintaining both tactile and erogenous sensation. The steps of metoidioplasty are technically similar to the repair of congenital chordee and penoscrotal hypospadias [5, 7]. The first step is to release and lengthen the hormonally enlarged clitoris through lysis of the surrounding clitoral attachments, including the fundiform and suspensory ligaments (Fig. 69.1). The urethral plate is incised to straighten the clitoris. The neourethra is constructed with an anterior vaginal flap and tubularized labia minora. Vaginal epithelium is excised, and the cavity obliterated. The labia majora are then utilized for scrotal reconstruction (Fig. 69.2).

69.2.2 Phalloplasty Surgery Overview

Historically, the ideal phalloplasty was described as producing an (1) aesthetically pleasing neophallus with a (2) neourethra that permits standing micturition and (3) enough bulk to accommodate a prosthetic stiffener while (4) providing tactile and erogenous sensation and (5)

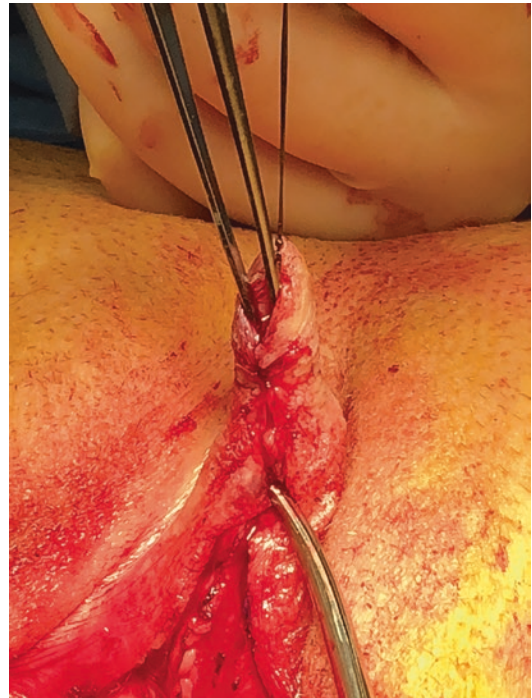


Fig. 69.1 Phallus lengthening and urethral lengthening in metoidioplasty



Fig. 69.2 Flat male-type perineum after vaginectomy. Scrotoplasty using labia majora flaps, a technique used in both phalloplasty and metoidioplasty

being reproducible with (6) minimal donor site morbidity [8]. Patients wanting the ability to achieve penetrative intercourse will preferentially choose phalloplasty.

The components of the neophallus urethra can be separated into its distinct component segments. These include the native urethra, fixed urethra (*pars fixa*), pendulous urethra (*pars pendulosa*), and the urethral meatus (Fig. 69.3). Where the fixed urethra is anastomosed to the native and pendulous urethra tend to be the epicenter of many phalloplasty complications. In a recent review that included 11 studies with a total of 665 patients undergoing radial forearm flap phalloplasty, the average number of strictures and/or fistulae per patient was 0.51 (range 0.2–0.8) versus 0.27 in patients with metoidioplasty [6].

A variety of phalloplasty techniques have been described in the literature, including radial forearm flap (RFF), anterolateral thigh (ALT) pedicled or free flap, latissimus dorsi free flap, suprapubic pedicled flaps, and osteocutaneous free flaps (mostly historical). Radial forearm free flap has emerged as the most commonly used method of phalloplasty followed by anterolateral thigh. Early attempts at free radial forearm flap phalloplasty had a 100% complication rate with total graft loss rate of 60% due to thrombosis [9]. In 2011, Doornaert et al. reported that 7.2% of their radial forearm flap phalloplasties demonstrated a minor degree of partial flap necrosis, while Ascha et al. reported in 2018 a partial neophallus loss rate of 3.4% [10, 11]. Phalloplasty technique has advanced a great deal with great acceleration in recent years, but complications still abound. The following are the most common urologic complications of female-to-male gender affirming surgery.

69.2.3 Urethrocuteaneous Fistula

Urethrocuteaneous fistula is the most common complication of both metoidioplasty and phalloplasty, with an incidence of 10% to 64% [9–14]. Generally older series report higher complication rates, while improvements in technique have resulted in lower rates of fistula in more recent series. While urethrocuteaneous fistulae can be

found anywhere along the urethra, they will almost exclusively form at the anastomosis between the fixed urethra to the pendulous urethra, also known as the anastomotic urethra [15]. In 1999, Fang et al. reported a urethrocuteaneous fistula rate in radial forearm free flap of 63.6%, of which 36% of these individuals healed spontaneously within 2 months. The remainder required an average of 1.55 surgeries to correct their fistula. All urethrocuteaneous fistulae occurred at the junction of neophallus to neoscrotum [12]. In the largest reported cohort of RFF phalloplasties to date, Doornaert et al. reported a urologic complication rate of 40% (127/316). Fistula was the only complication in 25% (80/316); 66% (53/80) of these fistulas closed spontaneously [10]. Recent advancements in phalloplasty technique have yielded an even lower fistula rate of 10% with a minimum follow-up of 6 months in 149 patients undergoing RFFF phalloplasty [11]. An important note is the impact of basic reconstructive tenets, such as multiple-layer closures. With vaginectomy, the bulbospongiosus muscle, which lines the vestibule, is available to form an additional layer over the newly created fixed urethra. Massie et al. have highlighted the importance of this layer by showing that omission of additional layers of vascularized muscle tissue, particularly in vagina-sparing phalloplasty, increased the risk of urethrocuteaneous fistula 400% from 14% to 56% [16]. Even with solid technical skills, urethrocuteaneous fistula will occur. Many will spontaneously resolve, especially in cases where the leak is small and there is a large amount of overlying tissues, such as a urethrocuteaneous fistula tracking through the neoscrotum. Many other fistulae will not spontaneously close and will need surgical intervention. For example, if the fistula is large and superficial, there simply is no tissue to heal over this area. The need for surgery is often obvious to the clinician in these cases.

Urethrocuteaneous fistulae usually present obviously with patients complaining of urinary leakage from an ectopic site when they void. Other symptoms include decreased force of stream, straining, incomplete voiding, dysuria and dribbling, especially if a urethral stricture is also present. Physical examination may reveal a

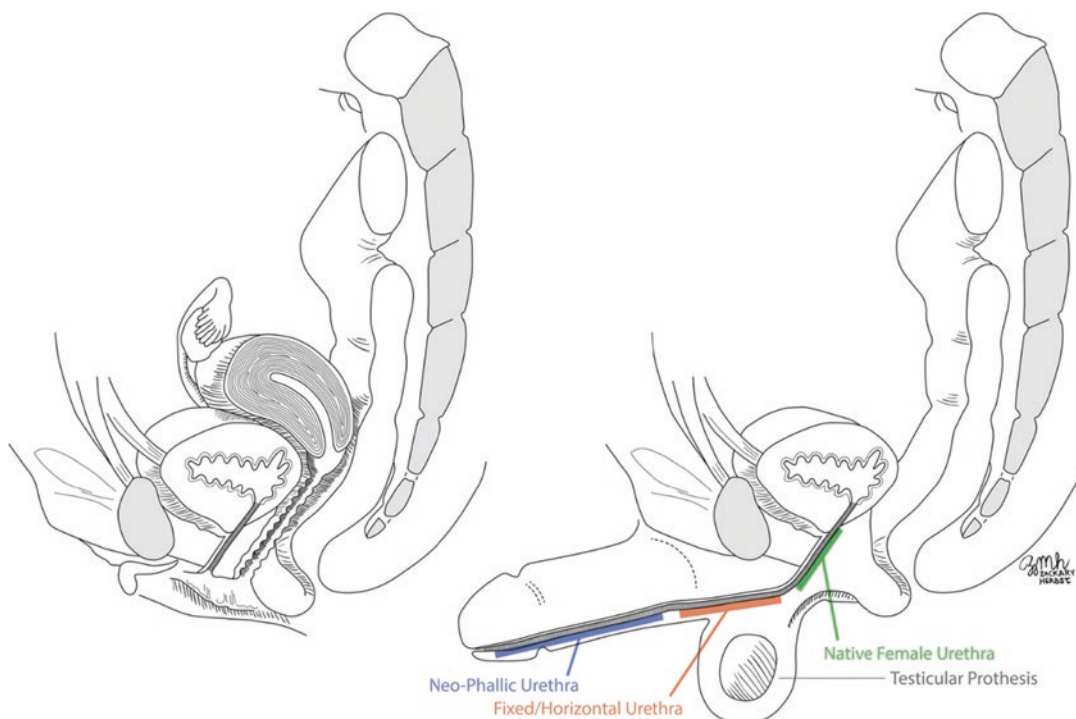


Fig. 69.3 Native female (left) and phalloplasty anatomy. The pars fixa (fixed urethra) is lengthened from the native urethra and continues on as the pars pendulans (penile/

neophallic urethra). The anastomosis between the pars fixa and pars pendulans is a common site for urethral complications. Used with the permission of the publisher [31]

visible fistulous tract, induration, erythema, tenderness, a fluctuant mass with expressible purulence, and urinary retention (aided by bladder scan). Ultrasound may be a useful adjunct to detect fluid collections, including abscesses, especially when there is a coexisting urethral stricture that may cause pooling and urostasis. Of note, while urethrocuteaneous fistula can coexist with a downstream urethral stricture causing increased voiding pressures, fistulae tend to occur early while strictures will present later.

The most useful diagnostic tool is a simple physical exam (Fig. 69.4). Once fistula is suspected, we generally schedule curative surgery and exam under anesthesia. Simultaneous urethral catheterization or cystoscopy is helpful for exact determination of fistula anatomy. The neo-urethra may be too narrow to accommodate a standard 17 Fr flexible cystoscope. In this case, a ureteroscope or pediatric cystoscope may be used. Further delineation of urethral anatomy may be performed with retrograde urethrography, but this is seldom required.



Fig. 69.4 Distal urethral fistula after previous metoidioplasty

69.2.3.1 Conservative Management of Urethrocutaneous Fistula

Most urethral fistulae are early events after surgery, often when a suprapubic tube is in place already from the original surgery. Surgeons may opt to continue urinary diversion for longer than the standard time (about 30 days for phalloplasty and about 21 days for metoidioplasty at our center) as initial treatment of fistula. However, data to support improved outcomes from longer urinary diversion times do not exist. Further, some experts at very high-volume centers in Austin, Texas and Ghent, Belgium believe that prolonged urinary diversion is not helpful after GAS. They assert that fistulae that are unlikely to spontaneously heal will never heal with any amount of prolonged diversion, and conversely that fistulae that will heal in time will do so with or without urinary diversion. More research is clearly needed to clarify the role of urinary diversion in healing of fistula. Ascha et al. report that when they do heal spontaneously, most of these fistulae will close within 3 months [11].

69.2.3.2 Surgical Management of Urethrocutaneous Fistula

The patient is usually placed in low dorsal lithotomy. Usually we pass a flexible cystoscope because this, together with external physical exam, is all that is needed to understand the anatomy well. Fistula repair follows the standard template: closure should be performed in many nonoverlapping layers. Local advancement flaps of well vascularized tissue should be used if possible. If a urethral stricture is present in close proximity to the fistula, then they should be repaired simultaneously; the stricture and fistula can often be removed entirely and anastomotic urethroplasty performed. In cases where urethral strictures are to be treated with a first stage Johanson urethroplasty, the urethrocutaneous fistula will be incised and effectively treated. If the urethral stricture and urethrocutaneous fistula are separated by a significant distance, then two separate operations should be done.

69.2.4 Urethral Stricture

Methods of urethroplasty at the time of metoidioplasty or phalloplasty all share the commonality of requiring long suture lines and anastomoses. These blood supply “watershed” points are the epicenter of stricture formation, the incidence of which ranges from 13.7% to 57.1% [10–12, 14, 15, 17]. Lumen et al. reports that the rate of urethral stricture by location after phalloplasties are the urethral meatus in 15%, pendulous urethra in 24%, anastomotic urethra in 41%, fixed urethra in 13% and multifocal in 8% [18]. In our practice, we have found that virtually all phalloplasty strictures are short (<2 cm) and almost universally located at the anastomosis between the pars fixa and the distal skin (penile) urethra. The remainder are distal, meatal type strictures, generally caused by distal flap loss and scarring over of the previously well-open meatus. Each of these entities have their preferred approach which we will describe in the following section.

The diagnostic workup for urethral strictures is similar to urethrocutaneous fistula. Imaging the urethra is important to determine stricture length. The surgical approaches are essentially the same as those applied to native urethral strictures: dilation/DVIU, anastomotic, first stage Johanson followed by possible second stage, buccal or skin grafts when necessary and the use of flaps for more complex repairs. Despite these many options, we have found that almost all phalloplasty strictures today are amenable to either EPA or Heineke-Mikulicz urethroplasty. One important precept not to be violated is to allow enough time to pass for post-surgical inflammation to fully resolve and regain strength and elasticity. We prefer to wait at least 6 months. In rare cases we will reluctantly proceed with repair in as few as 4 months if the tissue has healed quickly.

When urethral stricture presents prior to the 6-month mark, the surgeon must use temporizing measures for urinary drainage. Options include urethral dilation (often repeatedly), direct vision internal urethrotomy (DVIU) or suprapubic

cystotomy. Success of DVIU as a definitive treatment for urethral stricture is extremely low at 13% [19]. As in natal males, an extremely short stricture may enjoy success with DVIU according to some reports; however, we ourselves have not found DVIU useful as a definitive treatment [20, 21]. Unlike natal males who have a robust blood supply in the corpus spongiosum, the neophallus has a tenuous blood supply and it is our experience that hypoperfused, scarred skin is resistant to any treatment other than excision or staged urethroplasty. DVIU and urethral dilation should only be used as a temporizing measure to reach the 6-month mark at which point definitive surgery may proceed.

69.2.5 Urethral Stricture after Metoidioplasty

Metoidioplasty urethral stricture can be thought of as two basic entities: meatal stenosis versus all other types of stricture. If only the meatus is involved, then a standard meatoplasty may suffice. If, however, the stricture is more substantial than a meatal stenosis, then the options are either a single-stage buccal mucosa graft dorsal inlay versus a staged Johanson-type repair. A single-stage buccal mucosa dorsal inlay is preferred when the patient has a short urethral stricture.

Otherwise, the author prefers to perform a staged Johanson urethroplasty with buccal mucosal graft, as needed.

69.2.6 Urethral Stricture after Phalloplasty

69.2.6.1 Meatoplasty

Isolated meatal stenosis comprise 15% of all urethral strictures after phalloplasty [18]. This is most likely a sequela of impaired perfusion as the distal and proximal edges of the flap used to make a neophallus are necessarily the furthest from the blood supply. As in metoidioplasty, phalloplasty meatal stenosis may sometimes be easily treated by performing a standard meatoplasty, although longer distal strictures may require first stage Johanson urethroplasty or dorsal inlay single stage urethroplasty (Fig. 69.5). It is important to interrogate the entire urethra to rule out urethral stricture at another location, by performing a retrograde urethrogram or cystoscopy at the time of repair.

69.2.6.2 Short Urethral Stricture Repair

As previously stated, almost all urethral strictures after phalloplasty using current surgical techniques are short. If located in the distal penile

Fig. 69.5 Distal urethral stricture after phalloplasty treated with a dorsal skin graft and one stage urethroplasty



urethra, we prefer a meatoplasty for the shortest and most distal cases of meatal stenosis, and a staged Johanson approach for longer distal strictures. Unlike urethroplasty in natal males, the entire pendulous urethra is already composed entirely of skin rather than urothelium, therefore, the need for buccal mucosa is unnecessary and may even be counterproductive. Buccal mucosal grafts have a limited size, while flank skin can be harvested in nearly unlimited quantities. Also, buccal graft has poor graft take in the relatively hypoperfused phalloplasty milieu (Fig. 69.6). Usually we harvest full thickness skin grafts from the hairless flank, thin it on the back table to split thickness, and place it in the first stage.

The majority of urethral strictures will be found at the anastomosis of the fixed urethra. Very short strictures (~1 cm) are amenable to a Heineke-Mikulicz principle-based nontransecting

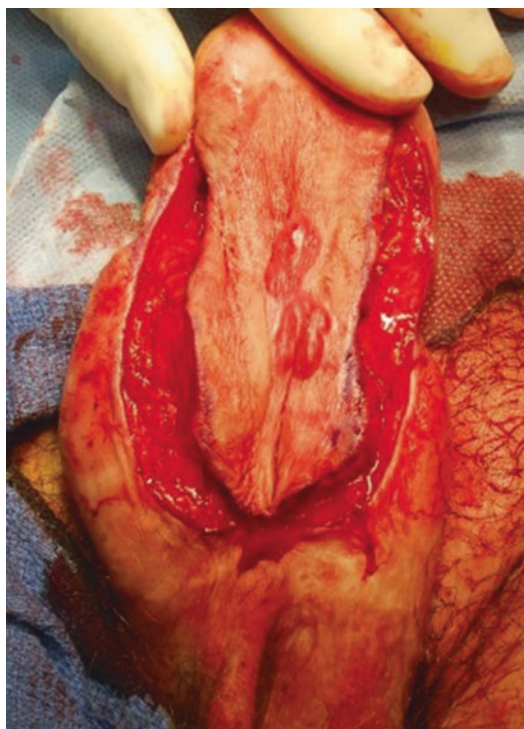


Fig. 69.6 Second stage Johanson urethroplasty for long penile urethral stricture in an older model “nonmicrovascular” phalloplasty. Note near total contraction of the previously placed buccal grafts, center. Poor performance of buccal grafts in phalloplasty strictures has led to us abandoning their use

anastomotic urethroplasty in which the stricture is incised longitudinally and closed horizontally. Placement of stay sutures on either side of the longitudinal incision helps facilitate a transverse closure. Nontransecting anastomotic urethroplasty success rate is reported at 58% [18].

When the urethral stricture is slightly longer (~1.5 cm) or particularly scarred due to fistula or infection, excision and primary anastomosis (EPA) is necessary. When performing EPA on a natal male, one must mobilize the urethra proximally and distally to create a tension-free anastomosis. This native urethral blood supply is absent in the neophallus, and urethral mobilization must be modified. We tend to free the proximal stump more thoroughly than the distal stump, and to spare the dorsal blood supply of the pars fixa by freeing up the ventral tissue connections most thoroughly. The strictured segment is excised, and the remaining segments of urethra are spatulated and anastomosed with absorbable suture, yielding a success rate of at least 57% with a mean follow-up of 34.9 months [18]. Any failures after primary anastomotic urethroplasty are treated with Johanson urethroplasty with skin graft.

69.2.6.3 Long Urethral Stricture Repair

Strictures longer than 2–3 cm are increasingly rare in the current era of microsurgery, but should one present, we prefer a staged Johanson urethroplasty. In their comparison of a variety of urethroplasty techniques, Lumen et al. report staged urethroplasty to be the most successful, with a success rate of 70% [18]. The first step is to incise the urethra along the ventral midline until normal caliber urethra is obtained. Skin graft is then laid down in order to widen the strictured segments of urethra (Fig. 69.7). Second stage Johanson urethroplasty is done 6 months later (Fig. 69.8). Alternatively, in extreme cases, first stage Johanson may be performed without plans for second stage. The patient will void through a hypospadiac urethral meatus or essentially a perineal urethrostomy if very proximal. This is seldom acceptable in the transgender community, where high value is given to the ability to stand to void.



Fig. 69.7 First stage Johanson urethroplasty of long penile stricture with split thickness skin grafts

Complex cases refractory to the above described procedures should be referred to centers of experience in both stricture repair and the specifics of phalloplasty strictures. The few experts in this rapidly evolving field are racing to devise innovative experimental protocols to elucidate the optimal approach to this challenging problem. For example, when the ventral aspect of the neourethra has extensive fibrosis due to infection and fistula, creation of a new urethral flap may be necessary to provide the blood supply to support a graft. Another situation is when there is a pendulous urethral stricture with a penile prosthesis in place. In this case, one must take extreme care repairing the urethra, especially when one would otherwise place a dorsal graft. This too, may be a case where one would employ a flap. Wilson et al. demonstrated that fasciocutaneous flaps from the scrotum/neoscrotum or thigh can successfully reinforce buccal mucosa grafts. In one case, a circumferential buccal repair was performed by tubularizing a dorsally placed buccal graft, creating a urethral plate with a ventral buccal graft supported

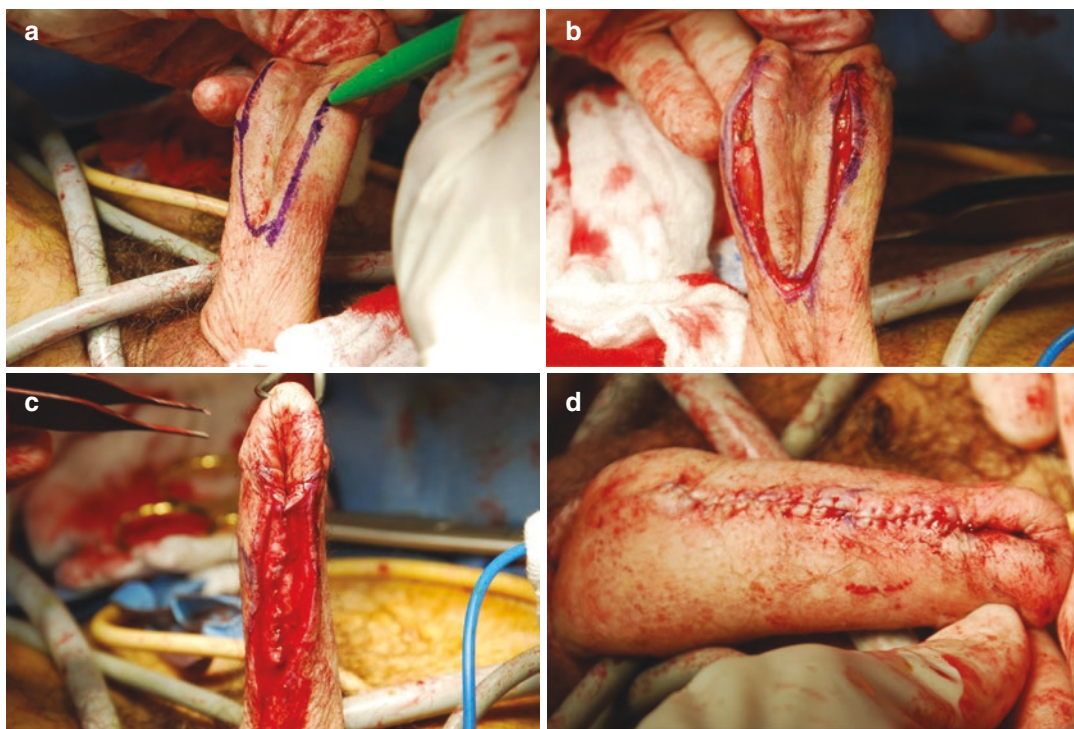
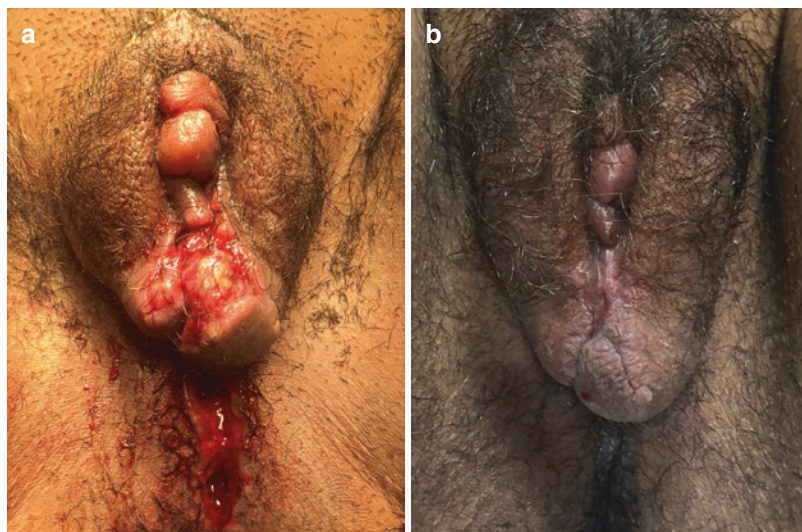


Fig. 69.8 Second stage Johanson urethroplasty of a long penile stricture. The prospective incision is marked and cut (a and b). The inner later is tubularized (c), and the outer skin layer is closed (d)

Fig. 69.9 (a) Post metoidioplasty dehiscence of scrotum and superficial vaginectomy wounds associated with a documented *Enterococcus fecalis* infection. (b) After wound culture, 7 days of wound care and culture-specific oral antibiotics, the patient was brought back for washout, minimal debridement and delayed primary closure, resulting in rapid near total wound healing



by a fasciocutaneous flap. Musculocutaneous gracilis flap have also been used when fasciocutaneous flaps are insufficient [22]. When used, flaps should be harvested from the side contralateral to the neophallus vascular pedicle.

69.2.6.4 Perineal Urethrostomy

Perineal urethrostomy must be considered after multiple reconstructive attempts have failed. It may also be performed if a patient no longer wishes to void standing or if they object to any further reconstructive surgery. While a perineal urethrostomy is often a measure of last resort, the salvage procedure itself has been reported to fail 62% of the time [18]. To perform a perineal urethrostomy, a 4–5 cm ventral urethrotomy is made along a segment of the fixed urethra, and it is approximated to the perineal skin. The urethrotomy will contract to some degree post operatively, therefore it behooves one to make a long urethrotomy.

69.2.7 Scrotal Necrosis

The neoscrotum is constructed from labia majora, which draws its blood supply from the internal and external pudendal arteries. Scrotal necrosis can occur on the side ipsilateral to groin dissec-

tion due to vascular compromise [11]. Most cases resolve after time. Delayed primary closure of significant scrotal dehiscence may be attempted. In our experience, success will be maximized by doing the following:

- obtaining wound cultures and starting culture specific antibiotics.
- using wet-to-dry dressings to decrease wound contamination.
- wound washout and thorough debridement of the scrotal area before closure.
- loose closure using nonabsorbable (e.g. 2-0 nylon) sutures.

Most wound complications will heal with time and wound care, but delayed primary closure may speed recovery (Fig. 69.9).

69.2.8 Persistent Vaginal Cavity

The most common method of vaginectomy is vaginal epithelial removal of the distal 1/2–2/3 of the vagina and thorough electrocautery destruction of the proximal 1/2–1/3 of the vaginal mucosa, followed by primary closure of the defect left by vaginal removal/ablation. Vaginal complications take three main forms:

1. Superficial nonhealing wounds. These are generally treated with wound care. If persistent to 6 months, we will treat with superficial re-excision and closure.
2. Deep nonhealing wounds. These are generally treated with wound care. If persistent to 6 months, we will treat with deep re-excision and closure, often with Y-V skin advancement flap assistance. In some cases, this may be associated with persistence of vaginal mucosa despite removal/ablation. Nikolavsky et al. recently reported that in their series of 40 neophallus stricture repairs, half were found to have large remnant vaginal cavities. Re-excision and obliteration of the vaginal epithelium was usually performed. Interestingly, histology showed that vaginal epithelium had regrown despite previous thorough vaginectomy in all specimens [23].
3. Complicated, deep vaginectomy wounds. These are often associated with chronic urinoma, perhaps from proximal (pars fixa to native urethra) urethral fistula, chronic urine pooling, and large inflammatory urinoma cavity.

In #3, we hypothesize an uncommon but troublesome scenario where urethral discontinuity at the pars fixa-to-native-urethra results in a persistent vaginectomy-space cavity, chronic perineal wound drainage, and sometimes urinary leakage from the perineum.

Symptoms and signs of persistent vaginal cavity include post-void leakage, a palpable mass, infection or abscess. We find CT or MRI helpful in the initial workup, although cystoscopy is always necessary to rule out urethral discontinuity. Ultrasound, RUG, and VCUG may be diagnostic adjuncts. Treatment includes urinary drainage with a urethral catheter or suprapubic tube followed by treatment of the underlying pathology. Vaginal remnants, if present, should be completely re-excised. Fistulae, if present, are closed. Chronic urinoma cavities are excised or ablated.

Total colectomy can be challenging in the transgender male. Groenman et al. have reported a robotically-assisted laparoscopic colectomy as a feasible means to more fully eliminate

vaginal epithelium [24]. It is not clear if the added expense and surgical time of this robotic technique will warrant its widespread use, or if current techniques will remain the standard of care.

69.2.9 Prosthesis Complications

Complication rates associated with penile prostheses implanted after phalloplasty are expectedly higher compared to cis-male penile prosthesis implantation. Overall revision surgery rates range from 23% to 43.3%, infection 4.2% to 11.9%, mechanical failure 4.2% to 18.4%, and dysfunction or malposition in 17.6% to 23.1% with mean follow-up ranging from 20 to 60 months [25–28]. The neophallus has decreased phallic sensation and a lack of corpora cavernosa, making penile prosthesis placement inherently difficult and complication prone. Patients with a sensate neophallus may enjoy some protection against erosion from chronic pressure and use-related trauma [10, 29]. Prosthesis implantation is delayed at least 9 months after phalloplasty to allow the neurotaphy to fully heal and become functional, and to make sure that any urethral complications have presented themselves. Falcone et al. argue that semirigid devices should not be used due to the constant pressure on phallic structures and increased risk of erosion while Levine et al. make a concession to the use of semirigid devices, but only in the sensate neophallus [25, 29]. We allow patients to choose either semi-rigid or inflatable penile prostheses, as we have not appreciated significant differences in complication rates between the two in our high volume center.

In native male anatomy, the corpora cavernosa are anchored to the pubic bone and pubic rami, and the surgeon simply inserts the cylinders into the corpora. One must find an alternate method of prosthesis anchorage in the transman to reduce the risk of erosion and migration. Exacerbating the problem is that the current array of penile prostheses is designed for native male anatomy and must be retrofitted to the transman. Some have resorted to constructing a neotunica out of a variety of synthetic material. The two largest

series to date investigating the outcome of penile prosthesis in neophalluses conclude that Dacron should be used cautiously for neotunical construction due to increased rates of mechanical failure of the device [25, 26]. Still, many wrap the cylinder with Dacron to facilitate fixation to the periosteum of the pubic bone or pubic ramus to prevent distal erosion [25, 27] versus fixation to the periosteum of the pubic ramus. Non-neotunical methods include placing a nonabsorbable suture through a rear-tip extender and affixing to the periosteum of the pubic bone [26]. This is our preferred technique. Yet another technique involves drilling a rear-tip shaped corticotomy into the pubic symphysis in which the rear tip extenders will sit. A nonabsorbable suture is placed through the pubic symphysis, rear-tip, and proximal end of the penile prosthesis to anchor the prosthesis [30]. The choice of a single cylinder vs. dual cylinder implantation must be made on a case-by-case basis. Neophallus size will dictate the size and number of cylinders it can accommodate. Hoebeke et al. notes that dual cylinder implantation can lead to poor aesthetic results, and we avoid dual cylinder implantation except in unusual cases [26]. Age, number of cylinders, rifampicin use, antibiotic impregnation, or silver Dacron were not predictive of infection or mechanical failure in the largest series to date [25]. Superiority of a particular IPP cannot be concluded with the current literature.

69.3 Complications in the Transgender Female

The components of genital male-to-female gender affirming surgery include orchiectomy, penectomy, clitoroplasty, labioplasty, and vaginoplasty, often performed in a single stage. The goals of surgery are both aesthetic and functional: the ideal technique achieves normal appearing female external genitalia while allowing for receptive sexual intercourse and clitoral orgasm. To that end, the ideal neovagina is moist, pliable, hairless, and at least 3 cm wide × 10 cm deep [31, 32]. The adequacy of the neovagina in providing a means for sexual stimulation is important to the

well-being of the transwoman based on survey data [33]. In patients who are not interested in penetrative intercourse or who want to avoid neovaginal dilation, “zero-depth” vaginoplasty has been put forth as an option [34]. Well established vaginoplasty techniques can be categorized into three categories [35]:

1. Skin grafts
2. Pedicled bowel segments
3. Penile-scrotal skin flaps, with or without the addition of scrotal skin grafts

Skin graft primary vaginoplasty has fallen out of favor because scarring leads to significant contraction of the tissue, resulting in neovaginal stenosis. Skin grafts also leave unsightly donor site scars [34]. Hybrid constructions using inverted penile skin flaps and scrotal skin grafts are our method of choice [36].

Rectosigmoid vaginoplasty has long been used in vaginoplasty (usually due to congenital absence of vagina in natal females) due to its ability to self-lubricate and because it was developed before reliable penile inversion techniques. Sigmoid colon is a tough tissue with an excellent blood supply, resisting contraction with healing [37]. Kim et al. reported length and diameter of the neovagina 3.4 years after rectosigmoid vaginoplasty were 13.2 cm and 3.8 cm, respectively [38]. Rectosigmoid vaginoplasty has fallen out of favor for transgender vaginoplasty. A complaint unique to this procedure is persistent malodor in up to 10% of patients [35]. Because abdominal and bowel surgery is inherent to rectosigmoid vaginoplasty, the patient will be exposed to the usual risks of this major intraabdominal surgery, such as anastomotic leak, ileus, adhesions and bowel obstruction, which are avoided in penile skin flap/scrotal skin graft techniques.

The penile skin inversion (flap) technique is the preferred technique of most transgender surgeons because it is hairless, sensate, and believed to be resistant to contraction [36]. A circumscribing incision is made proximal to the corona and dissection carried circumferentially along Buck’s fascia to the base of the penis. It is inverted and fixed in place between the rectum and bladder.



Fig. 69.10 Penile inversion vaginoplasty. The thinned scrotal skin is being sewn over a silicone vaginal form, to the inverted penile skin flap

The inverted penile skin can be incised and augmented with a skin grafts (Fig. 69.10), scrotal flap, or urethral flap if there is insufficient penile skin available [39]. The major predictors of post-operative complications, including need for transfusion, were a history of a bleeding disorder and hypertension [40].

Vaginoplasty requires dissection deep into the perineum in a space anterior to the rectum and posterior to the prostate and bladder, placing all these structures at risk during surgery due to proximity. Urologists are uniquely qualified to deal with complications with vaginoplasty as the pertinent dissection planes are encountered in prostatectomy, cystectomy, and posterior urethroplasty.

69.3.1 Neovaginal-Rectal Fistulae

Rectoneovaginal fistula is perhaps the most dreaded complication of vaginoplasty. Reported incidence across five studies ranges from 0.8% to

4.2% with a mean of 0.6% (14 in approximately 2240 primary vaginoplasties) [39, 41–44]. In the largest series of 1037 primary vaginoplasties, van der Sluis et al. reported a rectoneovaginal fistula rate of 0.8%, increasing to a rate of 6.3% in the 80 who underwent revision vaginoplasty. These cases involved the use of grafts, intestines, or pedicled flaps [44]. Most rectoneovaginal fistulae are an early complication, with diagnosis made within the first month postoperatively. Median time to presentation in the van der Sluis et al. series was 0.4 months (range 0.2–0.6) while Gaither et al. report a median time to fistula formation of 10.5 months in their series of 330 primary vaginoplasties. Rectoneovaginal fistula is likely a result of rectal wall thinning or perforation. Many surgeons use a rectal dilator to aid in the deep perineal dissection, which may put the rectum at risk for excessive thinning. Van der Sluis et al. report that 2.1% of their patients suffered iatrogenic rectal perforations, all of which were repaired at the time of injury followed by a low-residue diet for 5 days. Despite these measures, 17.4% of these patients developed a rectoneovaginal fistula [44]. Gaither et al. reported that two of the three of their rectoneovaginal fistulas were associated with intraoperative rectal injury that were recognized and closed primarily. Of note, they report that age, BMI and hormone replacement therapy were not associated with fistula formation [41]. Careful inspection of the rectum aided by digital rectal exam should be performed at the time of surgery [45]. Recently, robotic-assisted vaginoplasty has been used to facilitate a more precise dissection between the prostate and rectum – a dissection akin to the posteriorly approached robotic-assisted radical prostatectomy. This approach may decrease the already low risk of fistula further, although the cost benefit ratio of this more lengthy and complex surgical step has yet to be evaluated against the current gold standard. Robotic dissection of the vaginal space and incorporation of peritoneal flaps into the neovagina may prove to be useful in cases of inadequate penile size, often seen in patients who had purposeful puberty blockade with Lupron and adolescent growth of the phallus could not occur [31].

In the van der Sluis et al. series, all rectoneovaginal fistulae presented with foul-smelling neovaginal discharge or passage of flatus or feces, making history and physical examination the primary modality of diagnosis of these complications [44]. Further diagnostic tools include fistulography, barium enema CT, and endoscopy of both the neovagina and colon. Once identified, treatment consists of fistulectomy with primary closure. Local advancement flaps should be used with the use of pedicled flaps when necessary. In particularly complex or contaminated cases, delayed primary closure and intestinal diversion may be necessary [44, 46]. In repairing the fistula, one must be mindful for any future possible need to perform neovaginal revision with intestinal segments [44].

69.3.2 Neovaginal-Urethral Fistulae

Van der Sluis et al. reported 11 (1%) urethroneovaginal fistulae out of their 1082 vaginoplasties. Symptoms included neovaginal discharge during voiding, splaying of urinary stream, recurrent urinary tract infections, and position-dependent neovaginal urine discharge. Median time for diagnosis was 5.3 months (range 0.9–106.5 months). While physical exam is usually sufficient, diagnosis may require VCUG or cystourethroscopy. Fistulectomy and primary repair with local advancement flap is the preferred treatment modality. More complicated cases may require urinary diversion with suprapubic catheter. [44]

69.3.3 Neovaginal Stenosis and Inadequate Depth

The neovagina must be adequately wide and deep to allow for receptive sexual intercourse (if desired) and may be an important component of gender identity. That said, some patients will request a vaginal depth of up to 24 cm [47] whereas vaginal depth in natal females is 6.3 cm (4.1–9.5 cm) [48]. It is important to temper unre-

alistic expectation during preoperative consultation. Possible causes of neovaginal stenosis and loss of depth include impaired blood supply and infection. Skin retraction of up to 4 cm can occur in the first three weeks after surgery [36, 49]. Noncompliance with the prescribed dilating regimen, which some surgeons recommend for life, is a major contributor to neovaginal stenosis.

Rates of neovaginal stenosis have been reported in up to 13% of vaginoplasties [45, 49]. More recent cohorts, however, have exhibited lower rates with some centers using interesting new techniques to increase neovaginal size. Indeed, the best method of avoiding neovaginal shrinkage is to start with a large neovagina at the time of primary vaginoplasty. Gaither et al. report a 3% incidence of vaginal stenosis, however median follow up was only 4.4 months [41]. Papadopoulos et al. use a staged “combined technique” incorporating spatulated urethra, scrotal skin graft, and penile skin flap to maximize neovagina width and length. Achieved depth was 11.77 cm to 14.99 cm with vaginal stenosis occurring in 2.5% and loss of vaginal length in 2.5% [50]. A group from NYU have pioneered the use of robotics in vaginoplasty, using the daVinci robot (Intuitive Surgical, Sunnyvale, CA, US) to maximize neovaginal depth and aiding in fixation to the peritoneum, which may help reduce neovaginal prolapse and be useful in cases of arrested adolescence from hormonal therapy resulting in small genitalia [31].

On presentation, patients will complain that they have new pain or difficulty passing the dilator as easily or deeply as they once did. Intercourse may also be more difficult. The clinician should inquire about compliance with their dilation regimen. Physical exam will confirm the diagnosis. Treatment can start with resumption of a dilating regimen; however, this can be painful and ultimately discourage the patient further. Points of constriction can be identified in the operating room and a Heineke-Mikulicz stricturoplasty can be performed. If the amount of neovaginal tissue is insufficient for repair, additional skin grafts or perineal flaps may be used. We reserve pedicled bowel segment augmentation in refractory cases.

69.3.4 Urethral Stricture and Meatal Stenosis

While urethral meatal stenosis has been historically reported with a mean incidence of 5% across five studies (33 out of 658) [35], modern techniques have reduced this complication to a rate that is vanishingly low. For example, in their series of 332 vaginoplasties between 1995 and 2001, Rossi Neto et al. reported a urethral meatal stenosis rate of 40%, conceding at the time that their technique was under revision to improve this complication [49]. More recently, Gaither et al. reported ZERO cases of meatal stenosis in their series of 330 vaginoplasties performed from 2011 to 2015. In that series, 1.6% did report a deflecting or dribbling urinary stream [41].

Our preferred technique in creating the female neourethra involves transection of the distal bulbar urethra. We then spatulate the ventral side proximally until a catheter can be placed straight into the bladder without needing to negotiate the native bulbar urethral curve. The urethral meatus will be fixed at this position. A urethrotomy is made in the remaining dorsal urethra through which the neoclitoris will be placed and fixed. This results in the bulbar urethra being fixed in a widely splayed position, reducing the effect of contraction during the healing process, thus minimizing the possibility of meatal stenosis (Fig. 69.11).

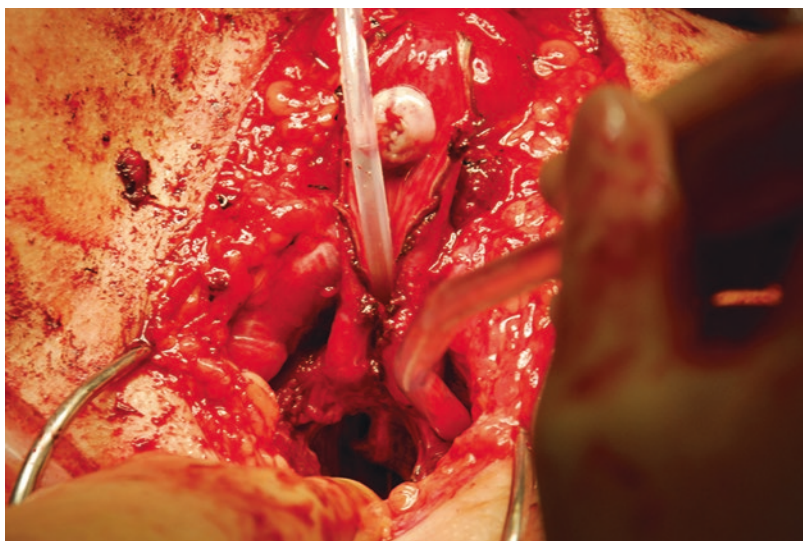
Fig. 69.11 Neourethral meatus. The bulbar urethra is widely splayed to form the neourethral meatus, minimizing the likelihood of urethral meatus stenosis

Patients with meatal stenosis will present with obstructive lower urinary tract symptoms, such as frequency, urgency, and dysuria, including the aforementioned deflection of the urinary stream. Physical exam is usually sufficient for diagnosis. Treatment consists of simple meatotomy or a Y-V plasty.

69.3.5 Neovaginal Prolapse

Neovaginal prolapse is a rare complication with contemporary studies reporting rates of 1% to 4% [49, 51]. Cause is likely due to inadequate fixation of the neovagina to its surrounding tissue when properly *in situ*. Vaginal depth is a key measure of satisfaction with surgery and this problem should be addressed. Patients often present complaining of a sensation that their neovagina is “falling out.” Diagnosis is made with physical exam. Exam under anesthesia will likely be necessary to fully delineate patient anatomy.

Treatment is aimed at fixing the neovagina to adjacent tissue. Some recommend fixation of the neovaginal apex to Denonviller’s fascia [51]. Another strategy involves fixation to the sacrospinous ligament. A series from Stanojevic et al. reports that all 62 cases of neovaginal prolapse treated with sacrospinous ligament suspension



were successful without recurrence with a median follow-up of 32 months. One must take care when performing this procedure due to proximity of the pudendal vessels and nerves, the sciatic nerve, the rectum, and the ureter. The authors note that the natal male pelvis allows for fixation closer to the sacrum, which minimizes the lateral deviation of the neovagina following this procedure [52]. Another option is to perform neovaginal sacropexy [53]; however, this surgery requires entry into the abdomen, which may be necessary in apical prolapse or if there exists another indication for abdominal surgery.

69.4 Conclusion

Gender affirming surgery is a complicated, difficult endeavor requiring the expertise of many medical and surgical disciplines. As social acceptance of the transgender community increases, so too will the number of patients who will seek surgical gender affirmation. Transgender surgeons are currently few in number, and patients must often travel great distances for gender affirming surgery. Therefore, because local reconstructive urologists will be called upon to help, they must be well-versed with the diagnosis and treatment of these complications.

Key Summary Points

- Urologic complications after gender-affirming surgery (GAS) are common. GAS is rapidly growing, and reconstructive urologists must be well-versed in the diagnosis and treatment of these complications.
- Options for genital female-to-male GAS include metoidioplasty and phalloplasty. The anastomotic urethra, a watershed area where the pendulous and fixed urethra meet, is the site of most complications of phalloplasty. These include urethrocutaneous fistulae and urethral strictures.

- Urethrocutaneous fistula is the most common complication of phalloplasty and tends to occur early after the index surgery. Many will spontaneously resolve. The remainder will require surgical repair.
- Most phalloplasty urethral strictures are short strictures amenable to excision and primary anastomosis or Heineke-Mikulicz principle-based nontransecting anastomotic urethroplasty.
- Many vaginoplasty techniques have been developed, but the penile inversion vaginoplasty has emerged as the most common technique.
- Complications of vaginoplasty include rectoneovaginal fistula, neovaginal-urethral fistula, neovaginal stenosis, neovaginal prolapse, and urethral stricture.

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Penile Prosthesis in Transgender Males

70

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70.1 Introduction

An ideal phalloplasty would be completed in one surgical stage with good aesthetic appearance, erogenous and tactile sensitivity, patency of the neourethra, sufficient rigidity to allow sexual intercourse and a volume sufficient to place a protected prosthesis [1]. Pedicled flaps transfer tissue from the thigh, groin or lower abdomen to reconstruct the neophallus, while free flaps transfer tissue from a remote location [2–5]. After phalloplasty, the neophallus is empty and flaccid. Erectile implants are needed to obtain rigidity and complete the reconstruction [6, 7].

The neophallus has decreased phallic sensation and a lack of corpora cavernosa, making penile prosthesis placement inherently difficult and prone to complication. Implant procedures are the last stage of reconstruction, typically performed 9 months to 1 year after phalloplasty upon return of protective sensation [8]. At this

time, vascular integration of the phallus should be optimized and urethral complications will have resolved or been corrected, thereby decreasing the risk of vascular complications during implantation, or unexpected urethral stricture that may be difficult to treat with a prosthesis in place [9].

When the phallus is constructed by use of a fibula flap or a radial forearm flap, rigidity can be achieved via transplantation of part of the fibula or radius, respectfully. However, donor site complications are substantially increased [10, 11] and these procedures are becoming increasingly uncommon. Furthermore, a permanently rigid phallus can be difficult to conceal and lead to embarrassment, or bone may resorb over time to varying degrees. The latissimus dorsi myocutaneous free flap may permit muscular contraction which might create penile rigidity, but also shortens the penis [12]. With the majority of the phalloplasty techniques, an inflatable penile prosthesis is used if erectile function is desired.

In the native male anatomy, the corpora cavernosa are anchored to the pubic bone and pubic rami and the prosthesis is inserted into the corpora. Phalloplasty lacks corporal tissue within which to anchor the implant proximally, therefore resulting in complications such as migration and malposition. Furthermore, a paucity of soft tissue distally can lead to erosion. Moreover, the current array of penile prostheses is designed for native male anatomy and must be retrofitted to

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the transman. This chapter will discuss considerations of penile prostheses after phalloplasty.

70.2 Types of Penile Implants

Penile prostheses or implants can be divided into three types: noninflatable, a two-piece inflatable implant, and a three-piece inflatable implant.

Noninflatable Penis Implants This includes semirigid malleable and nonmalleable rods. One or two cylinders are inserted into the penis. Often the implants are covered first in Gore-Tex vascular graft material (W.L. Gore & Associates, Flagstaff, AZ) to mimic a neo-tunica albuginea and potentially decrease erosion and migration. The rods have an outer coating of silicone and an inner stainless-steel core or interlocking plastic joints. These devices are entirely contained in the neophallus. Noninflatable implants are always rigid but can be positioned up or down and can be bent into different positions for erect and flaccid states. A wide range of sizes are available and these are easy to manipulate; however, these are the least commonly used implants. Semirigid devices may provide constant pressure on phallic structures and increase the risk of erosion, and should arguably be used only in the sensate neophallus. In our high-volume practice, we allow patients to choose either semi-rigid and inflatable penile prostheses; differences in complication rates between the two have not been appreciated.

Two-Piece Inflatable Penile Implants Hydraulically activated cylinders are surgically inserted into the shaft of the penis. The erection is provided by a hydraulic pump, which transfers saline from a reservoir within the neoscrotum to the cylinders in the penis. The release valve on the pump drains the saline from the cylinders into the reservoir for deflation. This implant is entirely contained in the neophallus and more easily concealed under clothing compared to the noninflatable implant. The two-piece inflatable prosthesis requires manual dexterity for inflation. The penis is not as rigid as a three-piece

inflatable penile implant. We tend not to use these devices, in favor of three-piece implants.

Three-Piece Inflatable Penile Implants Three-piece inflatable implants are the most commonly used penile implants. A single cylinder or pair of cylinders are implanted into the penis and a pump is implanted in the neoscrotum, taking the place of one of the testicle implants. The saline reservoir is implanted in the lower abdomen under the rectus muscle. By squeezing the scrotal pump, saline is transferred from the reservoir into the cylinders to create a more erect penis. Deflating the cylinders transfers the saline back into the reservoir to create a flaccid phallus. Compared to the two-piece inflatable implants, the reservoir is larger and function is generally better. This prosthesis is concealed within the neophallus. This implant is the most expensive and has a higher rate of mechanical failure compared to other implants, but is easy to use and most closely resembles the process of a normal erection.

70.3 Technique of Inflatable Penile Prosthesis Insertion

70.3.1 Background/Preoperative Preparation

The basics of this operation are very similar to that in a cis male, but some details are notably different and will be highlighted. The patient must be free of infection preoperatively (including a negative urine culture) and blood sugar must be under good control with A1c less than 7.5. Blood sugar should be in good control in the perioperative period. After clipping of excess hair in the surgical area, preparation includes gentle irrigation of the urethra with betadine solution, then standard extensive skin preparation (we perform a 15 minute prep using both betadine scrub, then chlorhexidine soap wash, followed by Duraprep (3 M, St. Paul, MN) or similar alcohol/chlorhexidine prep). Some surgeons cover the urethral meatus after prep with opsite or Tegaderm (3 M,

St. Paul, MN) during surgery to exclude this area from the sterile area. Standard draping is performed. Our protocol limits unnecessary foot traffic in the room, and after draping is complete, the person draping the patient has to change their gown and gloves. Outer surgical gloves are changed frequently, and always before handling the device for the first time. Antibiotic irrigation is prepared and used extensively throughout the case. The device itself is soaked in a 10 cc vial of intravenous sulfamethoxazole/trimethoprim mixed 1:1 with saline, although other antibiotic soaking regimens may be used. Patients are generally given a weight-based dose of vancomycin (15 mg/kg) and once-daily dose of gentamycin (5–7 mg/kg) in the 30 minutes before incision. We use exclusively Coloplast products (Coloplast Corp., Minneapolis, MN) as we find them more suited to transgender phalloplasty from a design standpoint.

Other small and “clean” surgeries may be performed at the same time (glansplasty, etc.), but clean-contaminated surgeries should be avoided (e.g., urethroplasty). If desired, we also place testes prostheses through a separate scrotal incision on the opposite side of the prosthesis pump, or rarely through the same pubic incision if the vascular pedicle to the phallus can be safely avoided.

We prefer to delay penile prosthesis until at least 9 months have passed from the time of phalloplasty, or in the event the patient has had a urethral stricture repair, 9 months from the last urethral surgery, to make sure that the critical period for any urethral stricture occurrence/recurrence has passed. Subsequent repair of urethral stricture may be difficult or impossible with a penile prosthesis in place.

70.3.2 Surgery

An infrapubic incision over the pubic bone is planned, and injected with either 1% lidocaine with epinephrine or 0.5% bupivacaine with epinephrine as pre-emptive anesthesia, to assist in pain control immediately after surgery and decrease bleeding during surgery. (Fig. 70.1) The incision is brought down to the pubic bone and then the underside of the bone exposed to seat the rear of the prosthesis. The midline abdominal fascia is incised and a sub-muscular tunnel created bluntly.

The space for the penile prosthesis is created with a long scissors, staying away from the urethra and vascular pedicle, to a point 1/3 of the way past the corona. (Fig. 70.2) Measurements are taken and an appropriate cylinder length chosen. The proximal centimeter of the cylinder rear tip is

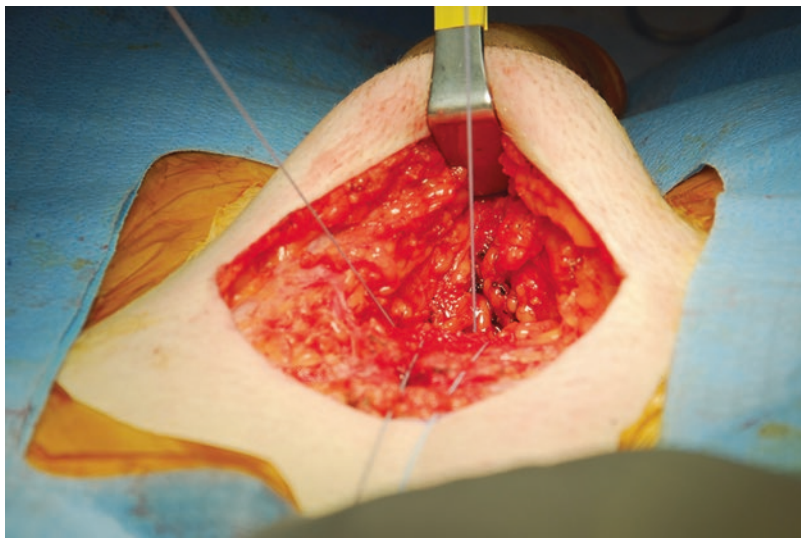
Fig. 70.1 Infrapubic incision over the inferior edge of the pubis. The incision is brought down to the bone, and the underside of the pubis cleared off to make space for the rear of the cylinder



Fig. 70.2 Sharp dissection of the penile cylinder space in the upper 1/3 of the phallus, being sure to travel along a fat plane away from urethra and skin



Fig. 70.3 Two titanium sutures are placed through the bone and periosteum of the inferior pubis, and placed through the rear tip of the penile implant



sharply removed. On the side opposite of the vascular pedicle, scissors are used to dissect into the hemiscrotum to seat the pump as deeply as possible into the scrotum. The reservoir is placed and 100 ml water is filled into the reservoir to expand it fully and ensure that external pressures from local tissue are minimized (which might cause autoinflation later). Forty milliliters are removed to leave 60 ml in the reservoir. The rear tip of the cylinder is sewn into the inferior pubic periosteum/bone with at least two 2-0 Fiberwire titanium sutures (Arthrex, Inc. Naples, FL)

(Fig. 70.3). The cylinder is delivered into the penis. The pump is delivered into the scrotum and the tunnel closed. Appropriate tubing connections are made and the device is tested for appropriate functioning and placement (Fig. 70.4). The abdominal wound is closed in multiple layers, isolating the tubes from each other and burying the tubing as deeply as feasible in the wound. The suture line is glued with surgical glue to allow for immediate post-operative showering. If testes implant is desired, it is placed through an upper scrotal incision contralateral to the pump. An ice



Fig. 70.4 Final result after intraoperative activation of the prosthesis to ensure good positioning

bag is placed on the suture line immediately after surgery. Ibuprofen pain medications are used to augment narcotic pain medication after 48 hours, to minimize the risk of post-operative bleeding.

70.4 Complications

Complication rates of penile prostheses implanted after phalloplasty in transmen are higher compared to cisgender with revision rates ranging from 23% to 43.3%, infection 4.2% to 11.9%, mechanical failure 4.2% to 18.4%, and malposition in 17.6% to 23.1% [9, 13–16].

70.4.1 Infection

Infection is the most common and potentially serious post-operative complication after penile prosthesis in phalloplasty. Implant infection, when present, may require explantation of the device. Factors related to infection rate include:

diabetes, steroid-use, smoking, radiation, re-do or revision surgery, obesity, and prior renal transplantation. Surgical factors include preparation type and hair removal, device coatings on implants, use of drains, surgical experience and approach, minimal touch technique, and perioperative antibiotics [17–20]. As noted above, we utilize many strategies to reduce the risk of infection, including ensuring preoperative negative urine cultures, antimicrobial cleansing prior to surgery, hair clipping, soaking implants in antibiotics, and perioperative intravenous antibiotics. Patient comorbidities are also optimized prior to surgery, whenever possible.

70.4.2 Erosion

Partial or complete erosion may occur from several factors, including infection, oversized cylinders, or inexorable thinning of the phalloplasty over the tip of the prosthesis. Risk factors for erosion include semirigid devices, those with diabetes and patients who have undergone repeat implant surgery. Erosion has also been described as a complication of urethral catheterization and can be reduced by using inflatable rather than semirigid prostheses [21]. The absence of a tunica albuginea increases the rates of erosion in the trans population compared to the cisgender population. Partial erosion may be managed by distal corporoplasty or downsizing the cylinder. Complete erosion resulting in extrusion requires removal of the device and allowing wounds to heal by secondary intention.

70.4.3 Intraoperative Perforation

Perforation may occur due to difficulty encountered in safely creating a cylinder space in the phallus due to fibrotic tissue. Generally we create the space using long Metzenbaum scissors, navigating a tract which stays away from both urethra and skin edge. We generally only dilate once with the single largest dilator, because smaller dilations may increase the chance of perforation and are generally unnecessary. Irrigation fluid that

leaks from the skin or urethra may indicate perforation. Although no data exists suggesting it is safe to close skin perforations and continue with implant placement, we would generally abort the operation. Perforation of the urethra requires abandoning the procedure and returning several months later for placement of a new implant.

70.4.4 Voiding Complications

Penile prostheses are placed in patients with no clinically significant urethral stricture in place. However, penile dissection and swelling may cause urinary retention in the immediate post-operative period. This can be surgically urgent. It can be difficult or impossible to pass a catheter through a phalloplasty urethra, but attempts to pass a 14 French or 16 French cou   catheter may be prudent, with plans to attempt removal the following day. Bedside cystoscopy, wire placement, and placement of a Council Foley catheter may also be done. In some cases, urgent placement of a suprapubic tube may be necessary. In this scenario, the surgeon who performed the penile prosthesis places a flexible cystoscope and then chooses a spot high in the bladder dome, well away from prosthesis components.

70.4.5 Pump Migration

The pump may migrate, usually superiorly within the neoscrotum. This can make activating the pump difficult, and may be unavoidable in cases of small neoscrotums. To avoid this complication, we endeavor preoperatively to mark the most inferior edge of the scrotum and place the pump deeply in the scrotal pouch. The superior portion of pouch may be sutured shut to discourage superior migration, but this can be technically difficult through a suprapubic incision. Patients are instructed to pull downwards on the pump daily for a few weeks after surgery to ensure that it scars into position in the most dependent location.

70.4.6 Cylinder Crossover

In cases where two cylinders are used, cylinder crossover can occur due to inadequate dissection of the tract, due to scar tissue, or dilation that deviates from the midline. Crossover is assessed by placing both dilators within their respective tracts. If crossover is observed, a dilator should be placed in the non-affected side and a new tract is created in the crossover side. The cylinder is then placed in the crossover side, the dilator is removed from the non-affected side, and the second cylinder is inserted.

70.4.7 Hypermobile Glans

Hypermobile glans may be the result of undersized prosthetic, inadequate distal dilation, or tissue laxity. These can be corrected by cylinder adjustment, re-dilation, or plication sutures, respectfully.

70.5 Outcomes

Since the first scientific description by Puckett and Montey in 1978 [22], other groups have described implantation of penile prostheses in case series [23]. Neophallic prostheses have astronomically higher complications than cismale penile prostheses. This is mostly due to a lack of protective anatomic structures of the penis. Phalloplasty lacks corporal tissue within which to anchor the implant proximally, therefore resulting in complications such as migration and malposition.

For this reason, patients should be warned that multiple revisions may be required. Some surgeons construct neotunica out of synthetic material. The two largest series to date investigating the outcomes of penile prosthesis in neophalluses conclude that Dacron should not be used for neotunica construction due to increased rates of mechanical failure [13, 14]. Alternatively, the cylinder can be wrapped with polyethylene terephthalate to fixate the periosteum of the pubic bone to prevent distal erosion [13] or fixated to the

periosteum of the pubic ramus [16]. Our preferred technique is a non-neotunical method of placing a nonabsorbable suture through a rear-tip extender and affixing to the periosteum of the pubic bone.

In a retrospective review of 129 transmen with erectile implants by Hoebeke et al. [14] aggregate complication rates were determined to be 11.9% infection, 9.1% erosion, 14.6% malposition, 9.2% leak and 41% revision at a mean follow up of 30 months. Falcone et al. [13] conducted a retrospective single-center analysis of 247 consecutive transmen receiving penile prostheses. Two-staged inflatable prosthetic implantation was performed. First, an extraperitoneal reservoir placement was performed with glans sculpture and a single large testicular prosthesis was inserted into the labia majora. Thereafter, cylinder and pump placement were performed. A Dacron envelope was secured around the proximal and distal aspect of the cylinder to anchor the device to the pubic bone. The group reported a high satisfaction rate at 88%. Prosthetic infection occurred in 8.5% of patients with a revision rate of 43%. The overall 5 year device survival was 78%, and no one device was noted to be superior. On subgroup analysis, the only predictive factor associated with penile prosthetic revision was the type of phalloplasty, being higher in patients with infraumbilical pubic flap phalloplasty compared with radial forearm phalloplasty. No predictive factor was noted to be significantly associated with infection or mechanical failure on further analysis.

Despite the high rate of complications, the satisfaction rate of patients is high and comparable to prosthetic implantation in cismales. Patient and partner satisfaction in the Hoebeke study [14] reported a cosmetic and functional satisfaction of 88%, satisfactory phallic sensation in 83%, penetrative intercourse in 77%, orgasm in 61% and partner satisfaction in 60% [9, 13–16].

70.6 Conclusions

Nearly all phalloplasty techniques require insertion of a penile prosthesis to achieve penetrative intercourse. Implantation of penile prostheses in transmen is a complex procedure that yields high

satisfaction rates but also high complication rates and the need for revisions. There is no standardization of techniques; however, inflatable devices are often preferred [24]. Although many advances have been made, these devices remain associated with high complication rates. Long-term data on the use of erectile implants in transmen are still lacking. Improvements in current devices may be necessary to optimize outcomes.

Key Summary Points

- Penile prosthetics are generally the last step in gender-affirming phalloplasty and rely on the development of tactile sensation before placement.
- Complications are substantial and are most commonly from malposition, mechanical failure, infection, and erosion.
- Despite the high complication rate, satisfaction remains high.

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